Astronautics

A PUBLICATION OF THE AMERICAN ROCKET SOCIETY

AUGUST 1958

SPECIAL SECTION
ON HYPERSONIC FLIGHT

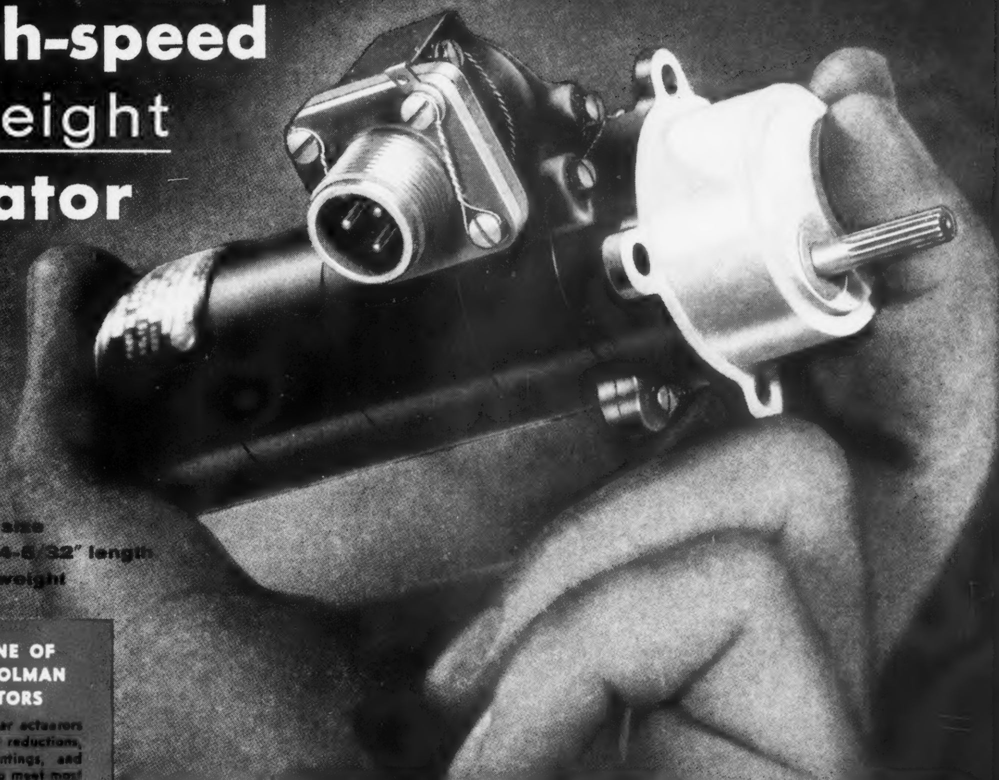

FORGING THE FUTURE OF SOLID PROPELLANT ROCKETRY...
THIOKOL
REDSTONE
DIVISION AT HUNTSVILLE, ALABAMA
At the Ordnance Missile Command, Huntsville, Alabama, Thiokol's Redstone Division pioneered the first successful, large, solid propellant rocket engines. Breaking the size barrier made possible such engines as today's Sergeant, and future solid propulsion systems for missiles in the IRBM and ICBM class.
Thiokol scientists at Redstone continue to lead in the development and application of the most advanced concepts in solid propellant rocketry.
Engineers, scientists—perhaps there's a place for you in Thiokol's expanding organization. Our new projects present challenging problems and the chance for greater responsibility.
Thiokol®
CHEMICAL CORPORATION
TRENTON, N. J. • ELKTON, MD. • HUNTSVILLE, ALA.
MARSHALL, TEXAS • MOSS POINT, MISS BRIGHAM CITY, UTAH
DENVILLE, N. J. • BRISTOL, PA.
®Registered trademark of the Thiokol Chemical Corporation for its liquid polymers, rocket propellants, plasticizers and other chemical products.

THE MARK OF QUALITY

BARBER COLMAN

Aircraft Controls

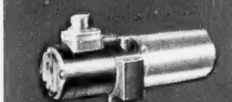
ew, high-speed lightweight actuator



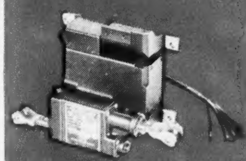
actual size
1-3/8" diameter, 4-5/32" length
0.56 lb. weight

WIDE LINE OF BARBER-COLMAN ACTUATORS

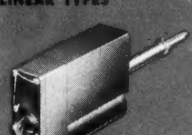
Rotary and linear actuators combining gear reductions, switching, mountings, and other features to meet most applications in their load-speed class. Illustrated below are but a few of the wide range of Barber-Colman standard and custom-designed units.



ROTARY TYPES



LINEAR TYPES



New Barber-Colman PYLC actuator drives 7.5 lb-in. load 95° in less than 200 milliseconds

Here's the new, advanced-design Barber-Colman actuator that is helping solve today's spacesaving and weightsaving problems. Primarily for aircraft and accessory equipment applications, Barber-Colman small, compact, lightweight PYLC actuators can be used as fuel-valve operators, ram air valve operators, optical filter changers, and for other applications where actuators, such as shown above, make ideal replacements for rotary solenoids. Actual tests of this unit indicate a life expectancy of 100,000 cycles. Standard units are rated up to 10 lb-in. with a wide range of speed-torque outputs. Available with split series, permanent magnet, or 400-cycle motor . . . optional radio noise filter . . . smooth, serrated, or special output shaft. Call your nearest Barber-Colman engineering sales office, or write direct for illustrated data sheet F-8017.

BARBER-COLMAN COMPANY

Dept. H, 1494 Rock St., Rockford, Illinois

Electrical Components • Aircraft Controls • Small Motors • Automatic Controls
Industrial Instruments • Air Distribution Products • Overdoors and Operators
Molded Products • Metal Cutting Tools • Machine Tools • Textile Machinery

BEARING FOR THE SPACE AGE—Creation of NORTRONICS, a Division of Northrop Aircraft, Inc., forms a unique combination of scientific knowledge, development techniques, and production experience specifically required for the space age. As any long journey begins with a first step, so the conquest of space begins at sea level. Scientists and engineers of Nortronics, who created and developed the world's first successful automatic intercontinental guidance system for use within the earth's atmosphere, are now applying their knowledge and techniques on a broad front to interplanetary navigation. Daily, also, Nortronics is building "hardware," ranging from precisely-accurate guidance systems in assembly line production, through complete ground support equipment for modern missiles and ordnance. Nortronics' extensive experience, capabilities, and physical facilities are now supporting weapon systems manufacturers to provide "security with solvency" for the free world.

NORTHROP DIVISION · NORTHROP INTERNATIONAL · NORTRONICS · RADIOPLANE

DIVISIONS OF NORTHROP AIRCRAFT, INC.

NORTHROP

BEVERLY HILLS, CALIFORNIA, U.S.A.

Astronautics

A PUBLICATION OF THE AMERICAN ROCKET SOCIETY, INC.

August 1958 *volume 3* *number 8*

EDITORIAL

HYPERSONIC FLIGHT

FEATURES

NEWS

DEPARTMENTS

ASTRONAUTICS is published monthly by the American Rocket Society, Inc., and the American Interplanetary Society at 20th & Northampton Sts., Easton, Pa., U.S.A. Editorial offices: 500 Fifth Ave., New York 36, N. Y. Price $9.00 a year; $9.50 for foreign subscriptions; single copies $1.50. Second-class mail privileges authorized at Easton, Penna. Notice of change of address should be sent to Secretary, ARS, at least 30 days prior to publication. Opinions expressed herein are the authors' and do not necessarily reflect those of the Editors or of the Society.

Astro notes

MISSILES

• Manned aircraft may be supplanted by missiles sooner than expected. AF Bomarc and Navy Talos are getting a good, hard look in an effort to determine to what extent they can supplant very expensive jet interceptors.

• Ramo-Wooldridge will serve as AF technical consultant on the Minuteman program, the same role it plays in the AF ballistic missile and lunar probe programs.

• Big push is on to simplify missile transportation, ground handling and launching equipment. Two ideas getting attention: Electronic checkout equipment of the "go-no go" type capable of being used with a number of missiles, and the use of helicopters for transportation and handling chores.

• Boeing delivered first Bomarc to the Eglin AFB missile range early in July, and Raytheon Hawk has just become operational with the Army.

• Propulsion contractors selected for Army's Nike-Zeus anti-ICBM missile are Thiokol for the booster and Grand Central Rocket for the sustainer and vectoring motors. Douglas will develop the airframe and Western Electric the ground guidance system, with Bell Labs handling overall systems supervision.

• North American's GAM-77 Hound Dog may get a new name. Present designation has never received official approval and NAA publicity men think Hound Dog sounds too "flop-eared." They've proposed Archer, Gauntlet or Dagger as substitutes.

LUNAR PROBES

• Contrary to reports appearing elsewhere, first U.S. lunar probe is scheduled to be launched by the Air Force, not the Army. First shot may come in September with a Thor-Able. Army will try later with its Juno II, made up of a Jupiter first stage and two, possibly three, upper stages of solid-propellant rockets.

• U.S. will probably beat the Russians in trying for the moon, according to one top Soviet scientist. Carefully avoiding discussion of the success of such attempts, Y. K. Federov, director of the Soviet Institute of Applied Geophysics, told newsmen at the Geneva talks on detection of nuclear blasts that Russia would stage its own lunar shoots "not quite so soon" as U.S. attempts scheduled to get underway next month.

SATELLITES

• Latest Vanguard failure was a severe blow to the entire program, since it put last of the fully instrumented NRL satellites into the drink, instead of in space. NRL is working on another satellite, but it's not likely to be ready before the end of next month, at the earliest. Additional satellites are even farther in the future, may not be ready until next year.

"Reconsideration" of Vanguard program is regarded as unlikely to end in abandonment of the program, largely because no other large-scale satellite projects are planned at this time.

RESEARCH

• Five-stage sounding rocket called Jason is being used to monitor above-the-atmosphere nuclear tests at Eniwetok. Under cognizance of AF Special Weapons Center, the solid-propellant Jason, with an altitude capability of 400–500 miles, uses an Honest John first stage, Nike boosters in the second and third stages, a Thiokol Recruit in the fourth stage, and a Thiokol T55 rocket in the fifth stage. Aerolab Development Co. is prime contractor for the program, which calls for firing of 20 to 25 instrumented vehicles to check radiation effects.

• Congress, shocked at statement by Allen Astin, Bureau of Standards Chief, that Russia is ahead of U.S. in high temperature measurements and instrumentation, is providing more funds for NBS in this area.

• AEC has announced completion of Kiwi-A reactor, to be used in Project Rover test late this year to determine feasibility of nuclear rocket propulsion.

• North American is using Navaho boosters in its recently announced RISE (Research in Supersonic Environment) Project. NAA engineers are reportedly unhappy over ordering of manned system with capability similar to that envisioned for the canceled Navaho.

RE-ENTRY

• Detailed data on re-entry of Jupiter nose cone has been obtained by the Army in its successful Gas Light project, involving optical measurements in the visible and IR spectra. Film sequence of Jupiter re-entry shows the rocket casing in flames behind the glowing point that marks the nose cone itself.

• Cornell Aeronautical Lab has received a $200,000 AF contract to study flight control of manned space vehicles during and after re-entry. CAL will use its specially modified T-33 aircraft to stimulate characteristics of such vehicles.

• Air Force's successful 6000-mile shot of its mouse-carrying Thor-Able, forerunner of upcoming lunar probes, is reportedly longest flight of any ballistic missile launched by U. S. to date. The combination Thor-Vanguard missile used is the same AF plans to use for its moon shot. Unfortunately, the re-entry nose cone and mouse have not been recovered although telemetry data had been received over the full course of flight.

TRACKING

• Recent disclosure of Army plans to build 85-ft radio telescope at Camp Irwin, Calif., to track lunar probes spotlights growing interest in such devices. Army scope, to be operated by JPL, will have movable antenna, capability of automatic tracking of lunar and other space vehicles generating radio signals.

INDUSTRY

• United Aircraft's long awaited entry into the missile and astronautics field came late in June with establishment of Missiles and Space Systems Div., to be headed by Wright Parkins, UA vice-president for engineering, and Norden Div., formed after purchase of Norden-Ketay, Perry Pratt, former engineering manager of Pratt and Whitney, has been named vice-president and chief scientist, in charge of UA advanced technical projects in both missiles and manned aircraft.

• Merger trend shows no signs of letting up. Latest move: Merger of Thompson Products and its subsidary, Ramo-Wooldridge. Move followed recent announcement that R-W's Space Technology Labs Div. had been established as a separate subsidiary corporation, wholly owned by R-W.

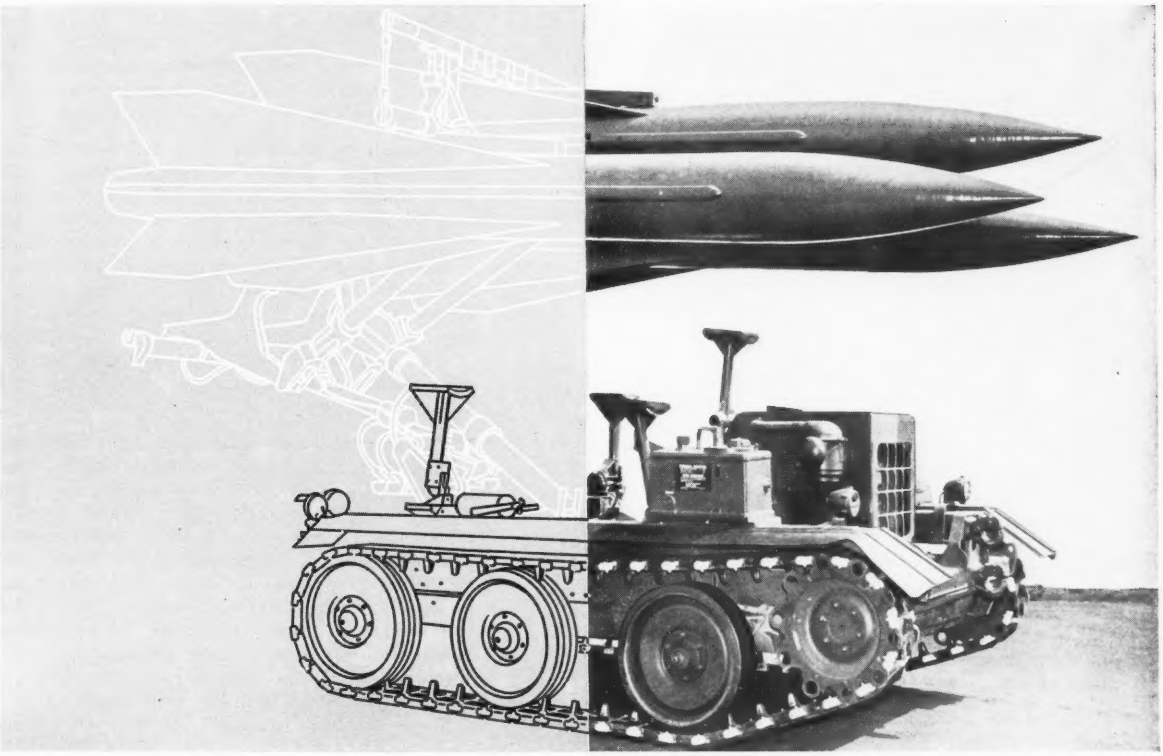
• Missile firms, both old and new, are concerned over growing tendency on part of contracting agencies to keep doing business at the same old stand, rather than to go to new contractors, when new projects are planned.

MEETINGS

• Astronomers at the American Astronomical Society's 100th meeting in Madison, Wis., agreed space flight was revolutionizing the science and that 10 years from now most astronomical observations would be made from points above the earth's atmosphere. This feeling was bolstered by an NRL paper on the new technique of rocket astronomy. Reporting on the firing of an Aerobee-Hi at White Sands last March, the paper noted that ultraviolet scanners, with which the rocket was equipped, had revealed hitherto unsuspected clouds of ultraviolet light of an intensity so great as to block out some of the brightest stars.

...speaking of

Missile Ground Support **MOBILITY**

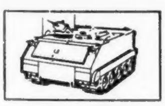


WE TAKE IT FROM CONCEPT TO COMPLETION

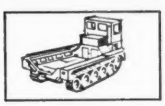
Few firms, if any, in this country can offer you the complete capabilities and experience FMC can provide in the field of mobile military equipment. Over the past 17 years, FMC has designed and built more types of military-standardized tracked vehicles than any other company in America. This background of experience is currently being applied to missile ground support equipment projects. Starting at the design concept phase, on through development, engineering and production, FMC provides a single source of coordinated responsibility. Also, important savings in time and costs can be effected by using FMC's fully integrated facilities devoted exclusively to defense production. And, contractors know that they can rely on FMC to meet contract delivery requirements – on schedule. For more information contact us, today. *Consult with FMC at the initial stage of project planning.*

Creative Engineers: Find stimulating challenge at FMC Ordnance Division

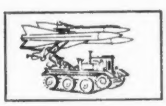
FMC'S PROFILE OF EXPERIENCE:



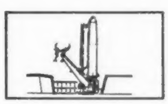
Multi-Purpose Vehicles



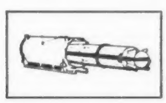
Prime Movers



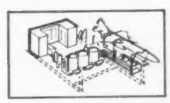
Transporter-Loaders



Launcher-Erectors & Power Units



Shipping & Storage Containers



Propellant Handling Systems

fmc FOOD MACHINERY AND CHEMICAL CORPORATION ®

Putting Ideas to Work

FOOD MACHINERY AND CHEMICAL CORPORATION

Ordnance Division

Missile Equipment Section 2-B

1105 COLEMAN AVENUE, SAN JOSE, CALIF.

Capital wire

News highlights from Washington

SPACE WEAPONS

• Formal Dyna-Soar contracts are expected to go out shortly to contractor teams headed by Martin Co. and Boeing. These will probably call for Phase I paper designs, construction of mockup sections and limited materials and aerodynamic testing.

Martin's proposal is said to be quite similar to that pushed for several years by Bell. Bell envisaged a three-stage glide bomber utilizing Titan ICBM boosters to achieve a range of 22,000 miles and an altitude of 40 miles. A lighter weight reconnaissance version of the glide bomber would function as a satelloid vehicle capable of making several earth revolutions at 100 miles. Significantly, Martin's team includes Bell as well as several members of the original Bell team.

Boeing's concept calls for far more system flight testing than the Martin vehicle. It is based in part on a scheme advanced by North American's Missile Div. to build a recoverable winged first-stage booster utilizing a pair of powerful jet engines which would continue to operate after burnout of the rocket motors. A pair of single-barrel engines, developing about 800,000 lb of thrust, would be ignited on the ground prior to launch to help rocket motors lift the vehicle, and then would power the empty structure back to the launching site after stage separation. Recoverable boosters would permit more extensive flight testing by averting loss of a major segment of the vehicle with each shot.

• That mysterious "bomb-powered rocket" mentioned in recent congressional hearings has been identified by ARPA. The scheme envisages the use of controlled nuclear explosions some distance behind the stout butt plate of a rocket vehicle. The latter would "ride" on a series of shock waves. ARPA has given General Dynamics a $1 million study contract to look into feasibility of the concept, including possible tests with conventional explosives on massive structures. Work will be performed by General Dynamics' John Jay Hopkins laboratory in San Diego.

ANTI-SATELLITE PROGRAM

• First "anti-satellite" program to be ordered by ARPA calls for construction of three continuous-wave Doppler radar stations in the U.S. to watch for "silent" satellites. Army will operate one complex at Fort Sill, Okla.; Navy will operate the others at sites near Bainbridge, Md., and San Diego. Each complex will have one transmitter and two widely separated parabolic receivers to secure trajectory and distance on the first U.S. pass. System will have a slant range of at least 500 miles and will be sensitive enough to detect even the size and attitude of inert satellites.

Data gathered on silent satellites will be of great importance in detection and tracking of possible ICBM's. Computers operating in conjunction with anti-missile defenses will compare all radar blips with known satellite orbits before alerting defenses.

MISSILES

• Navy is conducting design competition for an extremely long-range air-to-air missile called Eagle, with BuAer studying 16 systems proposals for the weapon. Eagle is to be a standoff weapon permitting a slow aircraft—perhaps turboprop-driven—to engage much faster jets at ranges far beyond those of Sparrow and Sidewinder, Navy operational air-to-air missiles.

• Although its propulsion system has been thoroughly proved, the Army's Sergeant ballistic missile is still about two years from operational deployment. Obstacle appears to be the development of a rugged, highly reliable inertial guidance system which will require only the ground support instrumentation which can be crammed into two small cabinets on the erector-launcher trailer itself. Sergeant will have the same range and accuracy capability as Corporal, but will require only one-fifth the supporting vehicles and one-half the manpower of the radio-guided, liquid-propellant Corporal.

• Army staged a remarkably successful demonstration of its missile capabilities before several hundred top military leaders and industrialists at White Sands and Fort Bliss early in July. Of nine missiles fired, eight functioned perfectly. (Sole exception was land-based Talos, handled by a Navy crew, on which new type warhead failed to function properly.) Most spectacular was the Hawk, which clobbered a low-flying QF-80 just five miles from the spectators. Most accurate was Lacrosse, which scored a direct hit on a two-by-four stake planted in the desert 16,500 yd from the launching point.

Some observers regarded the two-day missile shoot as an Army propaganda "blitz" to sell its missile capabilities in the face of strong AF competition. Curiously, however, no pitch was made for reassignment of 1500-mile Jupiter to Army units.

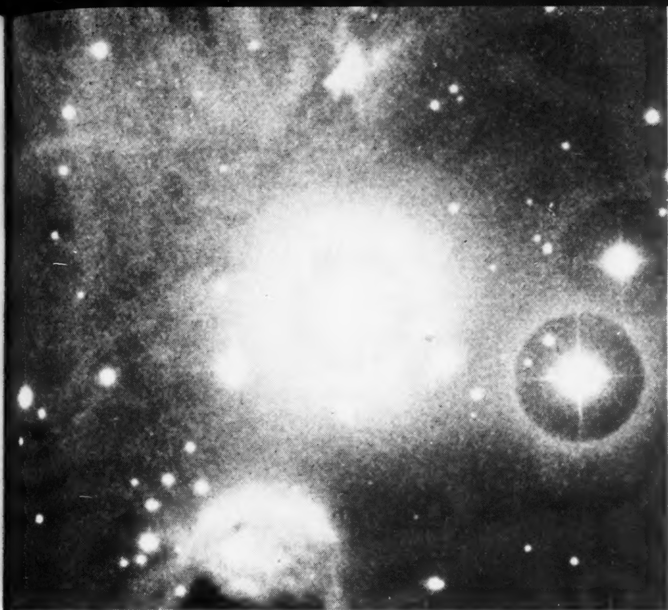
SATELLITES

• Meteor damage is blamed for the silencing of Explorer III's radio transmitters early in May, some two weeks ahead of schedule. Two of the satellite's erosion grids were ruptured during the first week in May when the 31-lb vehicle traversed the Eta Aquarids meteorite swarm. JPL Director W. H. Pickering suspects the tiny particles also damaged the two radios. Although operating independently of each other, both became erratic about May 8.

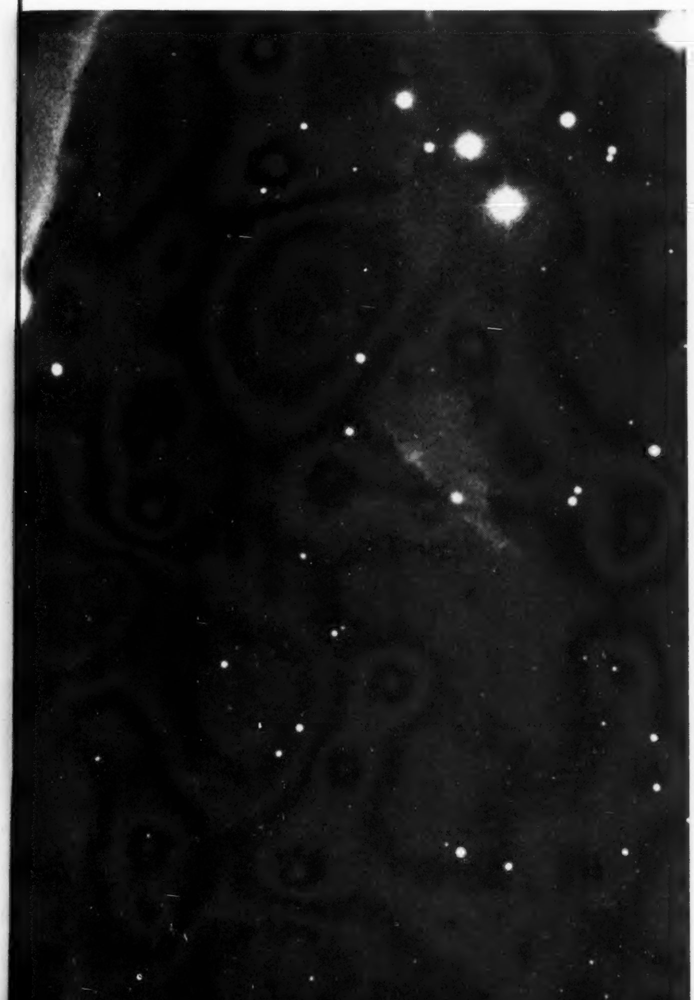
Explorer III fell back into the earth's atmosphere late in June after 93 days in orbit. It covered some 32 million miles during its travels in a lopsided orbit with an apogee of 1700 miles and a perigee of only 117 miles. Satellite's period shrank from 116 to 88 min just before it returned to earth, leaving Explorer I and the Vanguard test satellite still circling the earth.

• Navy's batting average with the Vanguard dropped to 0.167 in June when it failed to launch the fifth of six vehicles fired up to that time. It was the third straight failure to place a full-sized 21.5-lb satellite in orbit. Faulty fuel feed in the second stage was blamed for the failure. Next shot may be experiment designed to measure earth's cloud cover and radiation.


Missile Metal Machining



TECHNOLOGY



FLIGHT IN THREE MEDIUMS

Several things set the Polaris apart from other outer space weapons in the ballistic missile category, for the Polaris program involves a wholly new concept of weaponry.

1. It will be dispatched from beneath the surface of the sea.
2. It will be radically smaller than currently developed land-launched missiles, yet its payload will be as effective and its range the same as other IRBMs.
3. It will be the first operational outer space missile to employ solid fuel as a propellant.
4. It will travel through three mediums in a single flight—water, air and outer space.
5. Its launching base—a submarine—is not fixed but a mobile vehicle.

OUTER SPACE PROGRAM

Very little can be said about the Earth Satellite program at this time except that its success will necessitate advancing the state of the art in all sciences.

The Earth Satellite Project is perhaps the most sophisticated outer space program to reach the "hardware" stage in the U.S. today.

ENEMY SIMULATOR

The Lockheed Kingfisher Q-5 is the nation's fastest target missile, developed for the Air Force to test the accuracy of our newest supersonic weapons.

It is a ramjet target vehicle with Mach 2-plus capabilities. The Q-5 not only has speed to match the defensive missiles, but can also simulate a vast array of supersonic enemy missiles and airplanes attacking from great height. It is instrumented to score near misses and even theoretical hits without itself being destroyed.

It is recoverable from flight by parachute to be flown again, permitting weapon system evaluation to be conducted at greatly reduced cost.

for the record

The month's news in review

June 2—House okays NASA bill, sends it to Senate.

June 4—Chrysler Corp. gets DOD nod to set up Jupiter production line.

—ARPA Chief Scientist Herbert F. York says DOD will initiate production of million-lb thrust rocket engine by August, and that U.S. would attempt launching satellite as big as Sputnik III within year-and-a-half.

June 5—Reaction Motors develops rocket "jump-belt" for assault troops.

June 6—Navy fires Polaris in limited test, tags it successful though missile broke apart high over Atlantic.

June 10—ARDC Director Lt. Gen. Samuel E. Anderson's announcement that U. S. will try three moon shots in August, September and October is immediately refuted by ARPA Chief Roy W. Johnson, who says his agency will disclose when launchings will take place.

June 11—Senate Space Committee approves NASA legislation differing from that of House bill.

—ARPA Chief Roy Johnson tells Senate committee U.S. is perfecting a tracking fence that would detect any satellite passing over this country.

June 16—AF awards Dyna-Soar space glider contract to competitive teams headed by Martin Co. and Boeing.

—Senate passes its version of NASA bill, which is then sent to Senate-House Conference committee.

June 17—NRL discloses that Explorer III's voice has gone silent.

—Navy announces plans for $60 million radio telescope to aid in space exploration and serve as jam-free military transmitter for bouncing signals off planets to points around the earth.

June 19—ARPA says satellite tracking radio-radar network will be operative by end of 1958.

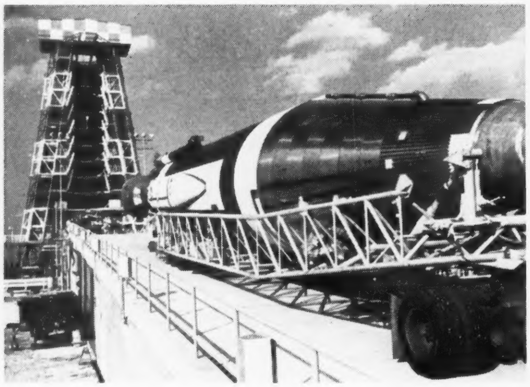
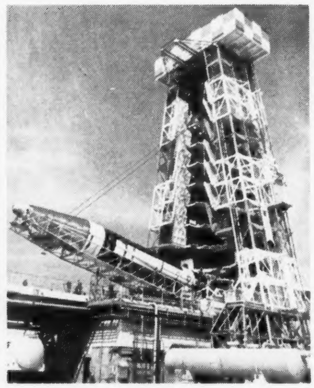
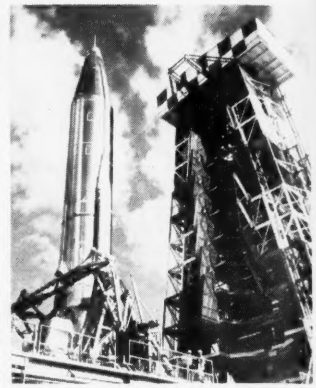
June 24—Navy successfully fires Polaris test vehicle.

June 26—Navy attempt to orbit a fully instrumented 20-in. Vanguard fails. Deputy Defense Secy. Donald A. Quarles says program will be reconsidered.

—AEC announces completion of an experimental reactor for research on nuclear-propelled rockets.

June 27—Snark ICBM is successfully launched for first time by AF's Strategic Missile Squadron at Cape Canaveral.

June 29—Smithsonian Astrophysical Observatory says it believes Explorer III burned up on June 27.

Preparing Atlas for Flight Testing

Preparatory to flight test, Atlas ICBM, in all its mammoth splendor, is eased toward launching platform (left) at AF Missile Test Center, Cape Canaveral, Fla. Two cables from erection hoist (center) raise the long-range missile onto launching tower; then gantry is moved away (right) and Atlas imperiously points heavenward.

Russians Explain Coded Signals of Sputnik III

The Russian Embassy in Washington has revealed in a report it released recently that coded signals from Sputnik III's Mayak radio transmitter, operating on 20.005 mc, are broken down as follows: When powered by solar batteries, the length of the first signal which follows the marker, equal to 300 millisec, lasts 150 millisec, and when fed by electromechanical batteries, it lasts 50 milliseconds.

The report went on to disclose that recordings of the luminescent cosmic ray counter are transmitted by an alteration in the length of the second and third (the last) signals from 150 to 100 or 50 milliseconds. The shift to the various lengths of signals, depending on the number of particles registered, is affected by a relay system. Intensity of cosmic rays measured is determined by frequency changes in the signals.

Space Technology Courses To Be Offered at UCLA

Intensive courses in Astrodynamics and Rocket Navigation, and Fundamentals of Rocket Propulsion will be given during August at UCLA by the University Engineering and Physical Sciences Extension. The former course meets from Aug. 4 through 15; the latter, Aug. 18 through 29. Future participants must have a BA in physical science or engineering, and can obtain information and applications from U. of Calif. Extension, Los Angeles 24.

Annual Award Set Up in Memory of Mark M. Mills

An annual graduate student award in memory of Mark M. Mills, former associate director of the Livermore Radiation Laboratory of the U. of California, who was killed in a helicopter accident last April at Eniwetok Proving Ground, has been established by the American Nuclear Society. Purpose of the award will be to recognize the outstanding graduate student working in the nuclear sciences.

Missile Firms Get Fast Tax Write-Offs

The Office of Defense Mobilization has resumed its program of granting fast amortization for tax purposes with issuance of certificates amounting to about $24.8 million to GE, Aerojet-General, Potter Aeronautical Co., and Fairchild Engine and Airplane Corp. on their planned missile and rocket research facilities.

The new tax write-off program, begun in March, embraces only those facilities needed to produce new or specialized services for the armed services or AEC, or to carry out research for these agencies, whereas the previous program, suspended in August, 1957, included a much wider variety of nonmilitary items.

Atlas Guidance Training

General Electric is setting up an AF training program in the operation of the company's radio-inertial guidance system for the Atlas ICBM at Cooke AFB, Calif. The program is slated to begin early in September.

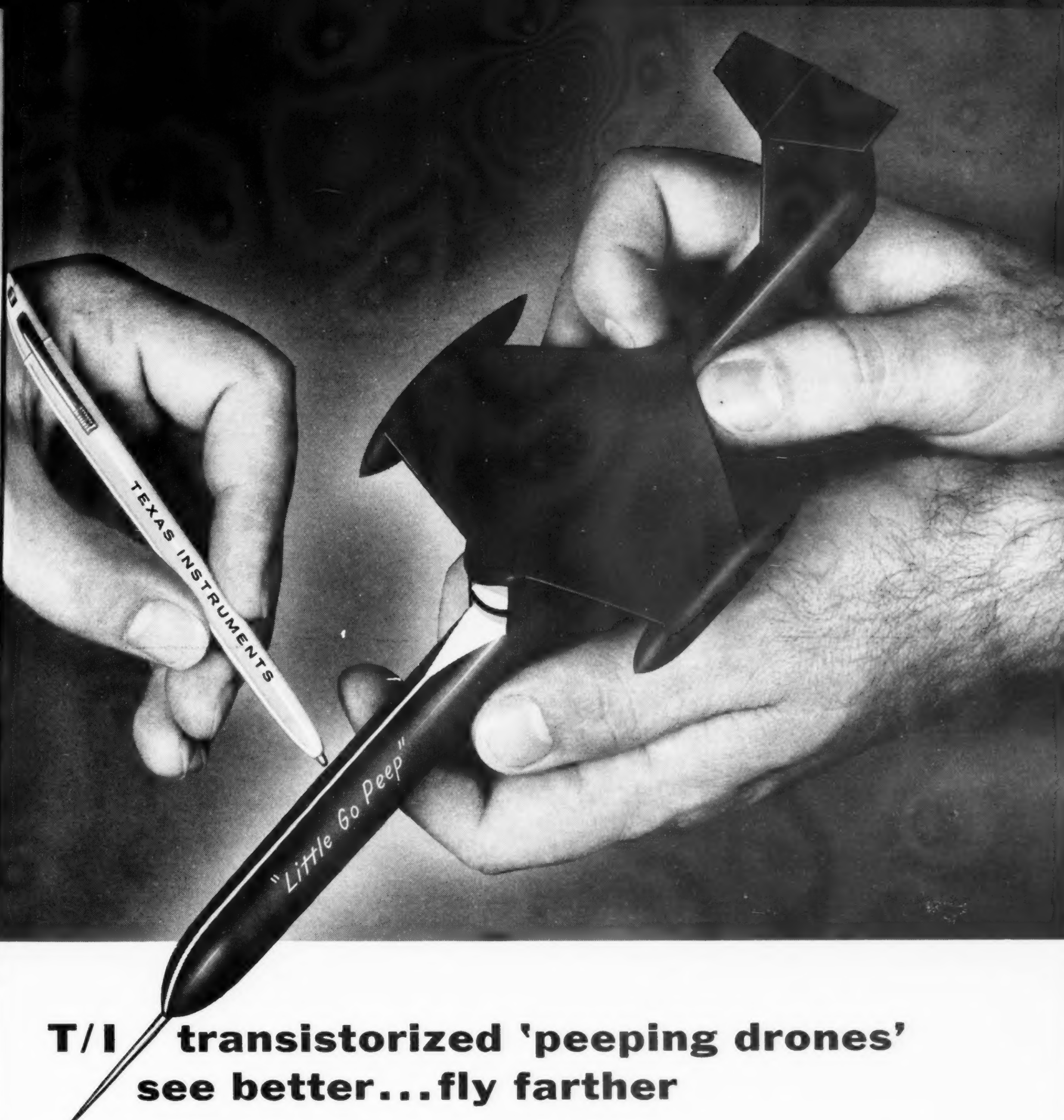
Mace Guidance System Proves Jam-Proof

Enemy jammers couldn't confuse the new Martin Mace Atran guidance system during six recent on-range and long-range Air Force test flights from Holloman AFB, N.M., to Wendover AFB, Ohio, at altitudes below 1000 feet. As many as six jammers simulating enemy countermeasures were employed to throw the Mace off course, but the vehicle continued on within a few feet of course.

The Atran guidance system, developed by Goodyear Aircraft, is a map matching system which relates a film strip to the terrain over which the Mace is flying, and does not depend on receiving electronic signals from the ground. Interchangeable with Atran is an inertial system, which the AF says gives the Mace complete invulnerability to enemy jamming, and also requires no ground control, emits no radiation and prevents electronic detection.

NSPE Hits Scholarship Bill

The National Society of Professional Engineers has wired Sam Rayburn, Speaker of the House, that a massive Federal undergraduate scholarship program would only hinder the progress made by engineering educational institutions in emphasizing the essential element of quality. The telegram opposed emphasis on undergraduate, rather than graduate, scholarships in a compromise Federal aid-to-education bill recently approved by a House subcommittee.



T/I transistorized 'peeping drones' see better...fly farther

Transistorized radar . . . and other Texas Instruments "electronic eyes" can peg the shape, location, motion, heat, and magnetic character of "targets of opportunity" . . . *relaying this vital data for action in those brief moments that the opportunity exists!* In manned or unmanned reconnaissance aircraft, TI's light, tough and compact electronics save fuel, space and weight while trimming maintenance and logistic problems.

Discussion of this advanced reconnaissance capability can be arranged on short notice. Authorized industrial or military personnel write or wire: Service Engineering Department . . .

TEXAS INSTRUMENTS
INCORPORATED
6000 LEMMON AVENUE DALLAS 9, TEXAS

apparatus division

systems management — reconnaissance, airways control, anti-submarine warfare, anti-missile, countermeasures, airborne early warning, navigation, attack control, missile systems, engine control.

equipments — radar, infrared, sonar, magnetic detection, computers, timers, telemetering, intercom, microwave, optics, detector cells, engine instruments, transformers, time standards, and other precision devices.

research/design/development/manufacture

In print

Of Stars and Men: Human Response to an Expanding Universe, by Harlow Shapley, Beacon Press, New York, 157 pp., illustrated. $3.50.

The Inhabited Universe, by Kenneth W. Gatland and Derek D. Dempster, David McKay Co., New York, 182 pp., illustrated. $3.95.

Exploring the Distant Stars, by Clyde B. Clason, Putnam, New York, 384 pp. $5.

These three volumes all concern themselves with the universe and what we can hope to find in it when space vehicles begin to take their long journeys first to the planets within our own solar system, then to the other solar systems in our own galaxy and, finally, to the millions of other galaxies, known and unknown, which surround us.

Harlow Shapley's short but exciting volume provides the personal answer of the eminent Harvard astronomer to one of the most provocative of all scientific questions: Will we find life existing on other worlds? His answer is a resounding "yes." Dr. Shapley not only believes that life exists elsewhere in the universe; he also feels that some forms of life may far surpass *homo sapiens* in intellectual capacity.

To back up his belief, the author summons up an imposing array of evidence not only from his own field, but also from biology, physics, chemistry, geology, and many other sciences, to show the conditions which produce life, and to prove that life can and must exist elsewhere in the universe. It is Dr. Shapley's firm conviction that life does exist elsewhere—in fact, that life may exist on as many as hundreds of millions of planets, and perhaps even more.

Dr. Shapley's arguments will not convince everyone, of course. However, this thin little volume, written with wit and eloquence, should go a long way toward shaking up our profound belief in the supreme individuality of man and awakening us to the fact that man is not alone in the universe.

Gatland and Dempster cover a good deal of the same ground in their book, but have expanded the subject to take in a considerably larger area. As Gatland states in his introduction, the three big questions the book attempts to answer are: Who are we? Where do we come from? Whither are we bound?

While the going tends to get a bit heavy at times, the research the authors have done and the importance of the questions they have attempted to answer make the book a fascinating one. Although they do not come up with an unqualified "aye" in answer to the big question about life elsewhere in the universe, as Dr. Shapley does, they too indicate that there is a good possibility that other forms of life exist.

And, in answering the questions they have posed, the authors present a fascinating rundown on the various fields of research which are involved in finding these answers, and in the philosophic and religious implications of the questions themselves.

Clyde Clason's volume provides a vast array of facts and figures about astronomy for the layman in an easily understandable and interesting fashion. The book covers both major subdivisions of astronomy, i.e., descriptions of astronomical bodies and of the motions and relations of these, and covers both subjects well.

Well-organized and eminently readable, the book, despite a few minor errors, presents a good picture of the current state of astronomy while posing the major questions which still remain to be answered. One big deficiency, however, is the failure to provide photographs—almost a must for any popular book on the subject of astronomy. **—I.H.**

Rocket by Air Chief Marshal Sir Philip Joubert de la Ferte, Philosophical Library, New York, 1957, 190 pages, illustrated. $6.

The better part of this book is devoted to the German V-1 flying bomb and the V-2 ballistic rocket; to the German efforts to develop and deploy these weapons despite differences of opinion in the High Command; and, on the allied side, to the work of piecing together the evidence from agents and friends and the thousands of photographic missions flown by the Air Forces.

The V-1 was eventually attacked on a vast scale by bombing its supply routes and launch sites, and by gunfire and fighters in the air. These methods were highly successful, and only a comparatively small number (2300) fell on the principal target, London. In contrast, the V-2 could only be attacked by obstructing its development. The great bombing raid on Peenemuende had as objective the destruction of the test facility and as many of the staff as possible. In this it was partially successful and no doubt imposed a significant delay, but sooner or later the V-2's had to fall.

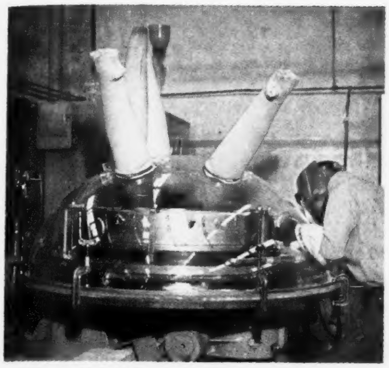
In one way they were not as disagreeable as the V-1. "For those who actually experienced the V-1 attack . . . the long drawn-out threat of the pulsating, flaming terror that flew across the sky was . . . mental torture. The effects of the V-2 were purely physical. Unheard and unheralded, its explosion was the first sign of trouble, and as the fall was very scattered and the numbers relatively small, the moral effect was very slight."

In his later pages Air Chief Marshal Joubert turns to the problems of modern defense, now that the advent of the megaton bomb has made major warfare unendurable. Somehow the ballistic rocket has to share this honor, perhaps because it is the one weapon which the flying men know they cannot attack, and so it is the rocket rather than the bomb that ends the utility of air forces of the WW II pattern. He is certain of this conclusion, however shaky the argument, and recommends that in the future the Royal Air Force be equipped only with surface-to-air missiles (against what?), with transports and reconnaissance aircraft. The Army can have the land-based ballistic rockets, the Navy can have them sea-based in submarines, and Britain can save a lot of money and manpower by the elimination of conventional armaments.

In the peace imposed by these unusable forces Britain will use propaganda to influence the large and potentially hostile population groups of the world, though what its message will be, other than that the British are jolly good chaps who always speak the truth, is not suggested. Eventually, through the advocacy of birth control, these large groups will be persuaded to disappear. We can then hope to see rockets employed for pleasant peaceful purposes like carrying the mail from London to New York without the necessity of air crews. Even passengers may be consigned in a similar manner, always supposing that the flying men can see some advantage in sending passengers aloft unescorted.

Marshal Joubert is didactic and provocative, and has blows for many in his path, from the American rebels of 1812 (sic) to minority groups who dictate U.S. foreign policy. He is at his best fighting the old battles over again. The new battles are more difficult, and perhaps his cronies at his

(CONTINUED ON PAGE 80)



COVER: *This special plastic chamber was developed by Solar Aircraft engineers for welding of titanium, a promising material for lightweight, heat-resistant hypersonic vehicle structural components, in enert atmosphere of argon gas.*

Astronautics

AUGUST 1958

From the Editor's Desk

With this issue, ASTRONAUTICS marks its first year of publication. It has been an exciting year, not only for those of us on its staff, but for all ARS members and, in fact, for anyone with an interest in rocketry and space flight—a year which saw man's first successful steps in the attempt to conquer space.

It therefore seems fitting that this first anniversary issue should be concerned to a large degree with hypervelocity flight and the structures, materials and processes likely to be employed in building the first true space vehicles.

The 18-page section beginning on the next page presents a detailed analysis of the problems involved in constructing such vehicles and some of the avenues of approach being followed to find an answer to these problems. The introductory article by George Gerard suggests that a new design approach may be necessary to produce the structural materials needed for hypervelocity flight. Subsequent articles review the possibilities inherent in metal, plastic, glass and ceramic materials. And, finally, Karl Fuechsel pictures one type of vehicle in which these materials may be used.

Also of interest in this issue is Eric Burgess' article (page 36) on single-roof testing, a new concept which may help increase missile reliability, and IAF President Andrew G. Haley's report (page 64) on his recent visit to Russia.

These features, plus full-scale coverage of the recent ARS Semi-Annual Meeting, some unusually interesting news stories and our regular monthly departments, add up to another outstanding issue.

—Irwin Hersey

New era dawns for flight materials and structures

The age of hypervelocity flight, inaugurated with certain missiles and proposed boost-glide rocket vehicles such as Dyna-Soar, brings with it a greater emphasis than ever before on material design technology

By George Gerard

COLLEGE OF ENGINEERING, NEW YORK UNIVERSITY, NEW YORK, N. Y.

George Gerard has been assistant director of research for New York University's College of Engineering since 1952. He graduated with a degree in aeronautical engineering from NYU in 1942, and received a doctorate of engineering there in 1950. From 1943 to 1948, when he returned to NYU as an assistant professor, he was a research engineer with Republic Aviation and the NACA. His chief interests are minimum-weight design and analysis of aircraft structures, mechanics of solids, experimental stress analysis and photoelasticity. Dr. Gerard has recently devoted his attention to the efficient application of high-temperature materials. He serves on several technical panels of the National Academy of Sciences Materials Advisory Board.

THE SO-CALLED "flight corridor," now virtually a cliche, dramatically illustrates altitude-vs.-velocity conditions for hypervelocity flight. This flight corridor as a thermal environment directs our attention to inadequately explored problems of materials and structures. The figures on page 21 depict the flight corridor and other flight regions, such as that typical for the long-range ballistic missile, in terms of altitude vs. velocity and heating.

As indicated in the figures, re-entry vehicles undergo intense transient heating. Heating rates as high as 500 Btu/ft^2 per sec have been stated for presently designed ballistic missile nose cones. Orbital re-entry bodies, particularly those that are manned, will be subject to lower heating rates because of the necessity for limiting decelerations. The total time a vehicle descending from orbit undergoes heating, however, will be considerably increased.

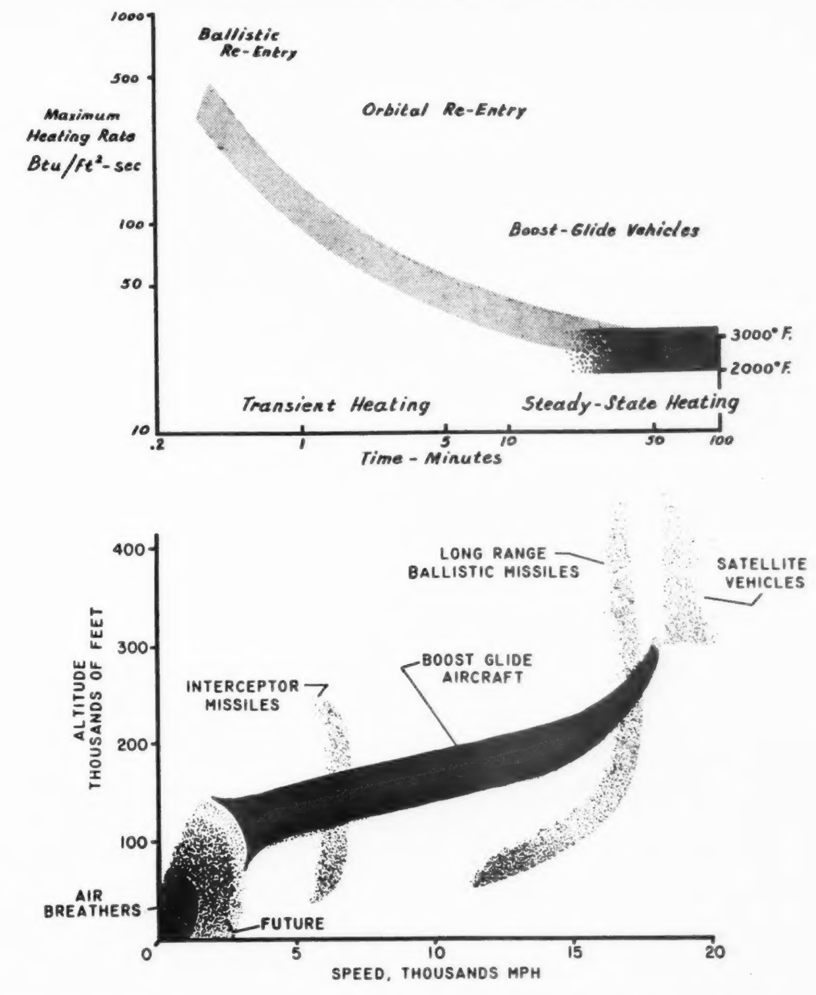
These vehicles, such as the boost-glide aircraft or glider released from a satellite, will be characterized by steady-state heating. Steady-state heating rates are an order of magnitude less than for re-entry vehicles, but the long periods of heating for them pose materials problems that, as of now, appear considerably more serious than the nose cone problem. The current material solutions for nose cones are based on transient heating conditions. These solutions do not have application in steady-state thermal environments.

Steady-State Heating Affects Structure

There are two distinct aspects of the boost-glide class of vehicle which present materials problems. Foremost is the leading edge structure, which may be subject to stagnation temperatures on the order of 3000 F. Fortunately, this structure is lightly loaded, which means materials may be selected primarily on the basis of suitable thermal and oxidation characteristics. However, the long heating times involved at 3000 F make this a particularly difficult problem to solve in terms of a reasonably light structure.

The second aspect of boost-glide vehicles centers about the load-carrying structure, which is generally sufficiently removed from

Velocity and Heating in Hypervelocity Flight



the stagnation regions so that maximum equilibrium temperatures are of the order of 2000 F. Because of the low wing loadings associated with boost-glide vehicles, some enthusiasts hold hopes for the use of heat-sustaining materials in load-carrying structures. Others are exploring the use of thermal protection techniques in which the load-carrying structure, shielded from the surface, operates at a considerably lower temperature.

Both approaches have merit, and signify our entry into a new era in material-structural development in which the ingenuity of the structures engineer in exploiting the desirable characteristics of materials through materials design is a necessity. A complete recognition of the importance of materials design holds great promise of achieving significant developments in lightweight, elevated-temperature structures.

In somewhat broad perspective, we have just left a long era in which the problem of selecting materials for the primary structure of aircraft was virtually nonexistent—that is, aluminum alloys were employed almost exclusively. Now the thermal environments associated with hypersonic weapon systems have opened a new era in which the problems of material development, selection, and fabrication have added a new dimension to the complexity of these advanced systems.

In the realm of large heat-flux transient heating, heat sink and ablation materials have been successfully employed for ballistic re-entry bodies. Considerable research is being directed toward the development of more efficient *heat-absorbing* materials—beryllium, graphite, (CONTINUED ON PAGE 46)

Metal forming for the missile age

Adaptation of present equipment, such as 50,000-ton forging presses, use of new techniques, such as explosive and cavity forming, and better exchange of information will help keep manufacturing up with design and development

By Alexander Zeitlin

ENGINEERING SUPERVISION CO., NEW YORK, N.Y.

Alexander Zeitlin is president of Engineering Supervision Co., which recently became affiliated with F. H. McGraw & Co., constructors and engineers. He was formerly a vice-president of Birdsboro Steel Foundry and Machine Co., and vice-president of Loewy-Hydropress and general manager of Loewy Construction Co. When with Loewy, he supervised and managed a large portion of the Air Force's heavy press program. He practiced consulting engineering in Europe for a number of years before coming to this country in 1938. His academic training includes a master's degree in mechanical engineering from the Institute of Technology, Kiev, Russia, and a degree in electrical engineering from the Institute of Technology, Berlin-Charlottenburg, Germany.

THE GRADUAL shift of emphasis from air-supported manned aircraft to unmanned aerodynamically unsupported missiles has required a fundamental change in design specifications and, of course, in construction materials and manufacturing methods.

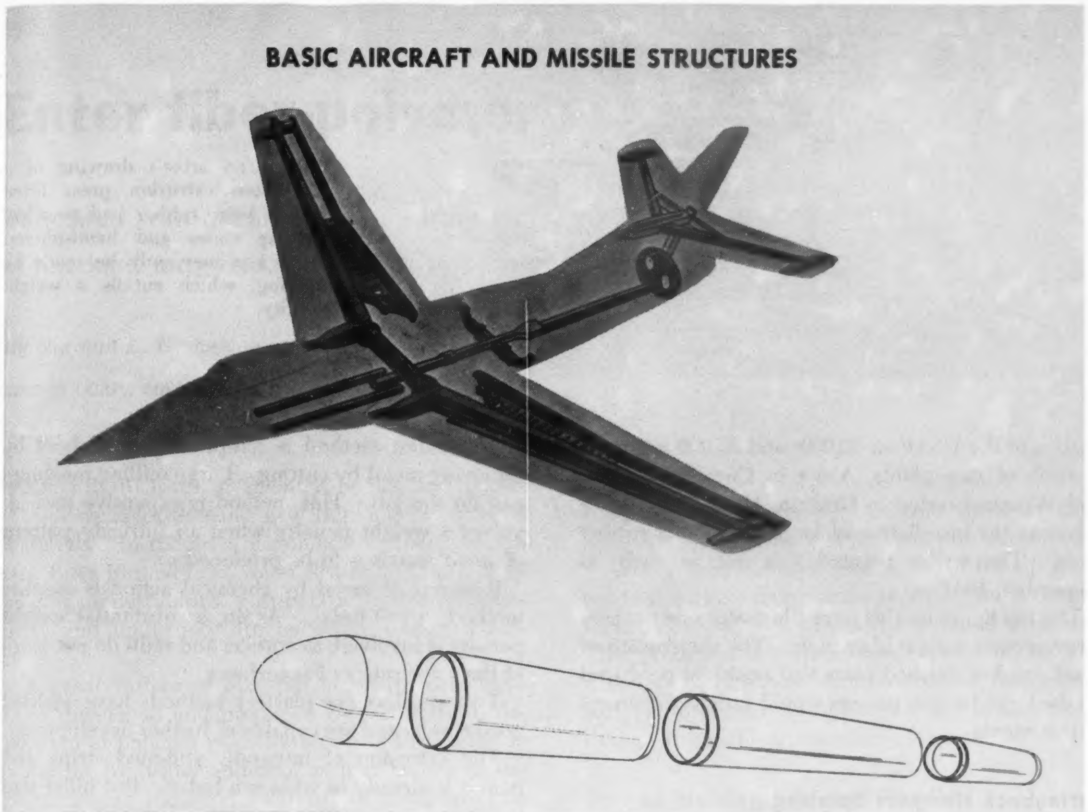
The drawings on the opposite page illustrate the basic change in the structure of the chief air weapon of WW II, and even to a few years ago, the aircraft, and the chief "air" weapon today, the missile. The aircraft structure consists of large closed die forgings and long hot-extrusions; it requires large aerodynamic surfaces, attached to the main structure by means of massive bulkheads, an air-pressurized compartment, etc. In contrast, the main missile structure consists of sheet metal possibly reinforced by ribs. Comparatively light rings and thin membranes replace heavy bulkheads. There is no "living space," and so forth.

Environmental conditions have changed as deeply and radically as structural design. And especially, the extreme speeds at which missiles fly bring environmental temperatures many times higher than the "heat barriers" discussed only a few years ago. These temperatures demand the use of new structural materials and new structural concepts, yet in terms of a basic problem with us since Kitty Hawk: Design for minimum weight.

We shall review here some of the accomplishments and some of the remaining problems in making the basic missile structure to minimum weight.

Close-Tolerance Production of Large Sheets Urgent

A most urgent problem is the production of large sheets to close tolerances. The difficulties with titanium in this respect are well known, and have resulted in the setting up of research programs, study committees, special investigations and similar measures. One of the results of these steps was the realization that production of a high-quality product requires equipment designed to proper specifications. Attempts to roll in a conventional manner small quantities of large sheets of high-quality titanium on mills designed to roll huge tonnages of commercial quality steel sheets could only produce poor results.



The basic structures of the aircraft and missile show why there has been radical change in metal forming methods. The aircraft employs large closed die forgings and long hot-extrusions, with surfaces attached to main structure by massive bulkheads. The missile, in contrast, employs light metal sheet with light ribs, rings and membranes.

That substantial improvements can be achieved by a proper analysis of equipment and methods has been demonstrated conclusively by several manufacturers. The major problem when using the existing equipment lies in the fact that the equipment is not rigid enough. Since it is impossible to increase the rigidity of the existing equipment, one should endeavor to reduce the relative value of deformation of the mill stand during rolling. This can be done by rolling several sheets simultaneously.

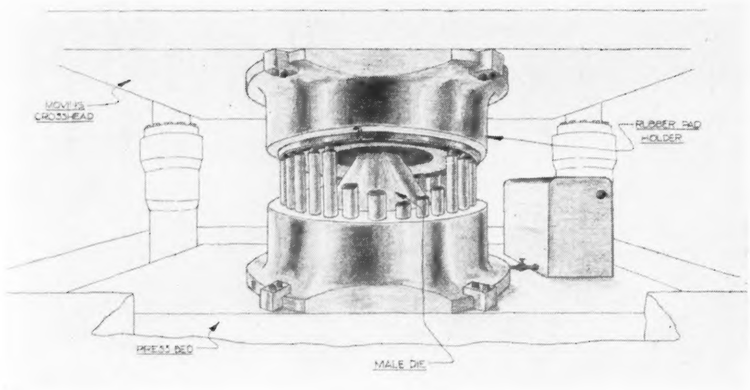
For all that, the final solution of the problem will lie in installing new equipment designed to a proper specification. This applies not only to titanium, but to stainless steel and to special alloys like Inconel. The problem of rolling sheets of brittle metals, e.g., beryllium, is advancing toward a solution by a radical change in manufacturing methods. Starting with powder and compacting it into sheets by rolling has produced promising results. A sintering operation completes the process. Good progress has been made in rolling high-temperature metals. Materials like molybdenum, however, must be properly protected against oxygen corrosion by either providing an airtight protective enclosure or by providing a proper protective atmosphere (surrounding the mill with an "envelope").

Sheets up to 120 inches wide, and sometimes even wider, are obtainable today for some metals.

Deep-Drawing for Cones, Hemispheres

Large cones and hemispheres present a major manufacturing problem. These structures entail a weight penalty because they are now made by welding several partial forms, and the welding is extensive to gain perfect joining. It has been realized a long time that most of these shapes could be deep-drawn successfully if the proper size of equipment was available.

Considering the comparatively small quantity of these shapes needed for missiles, the construction of a single-purpose equipment would require a prohibitive investment. Fortunately, the large forging



This is an artist's drawing of a 50,000-ton extrusion press fitted with a large rubber pad to allow forming cones and hemispheres. These can now only be made by welding, which entails a weight penalty.

presses of the USAF—a 50,000- and 35,000-ton press in each of two plants, Alcoa in Cleveland, Ohio, and Wyman-Gordon in Grafton, Mass.—lend themselves to the installation of large deep-draw rubber pads. The writer pointed this out as early as December, 1951.

The top figure on this page illustrates one of these large presses with rubber pads. The dimensions of blanks and of finished parts that could be produced on the large forging presses would satisfy all current requirements.

Springback Hampers Spinning

Another sheet forming method showing good promise for the future is high-power spinning. At present the method suffers from springback, in particular when secondary operations punch holes into the formed piece. Small pieces are being produced with subsequent die quenching now, but the equipment large enough to produce large shapes is not available and a very substantial investment would be required to procure it.

The production of large integrally reinforced panels has been a problem for a long time. Of several methods for making them in use today, none is yet fully satisfactory, but all show promise.

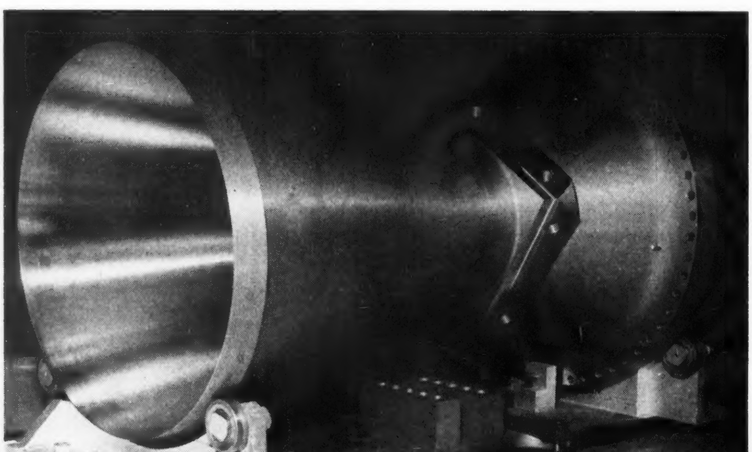
The oldest method is sculpturing of a sheet by removing metal by cutting. Large milling machines can do the job. This method is expensive and involves a weight penalty when an intricate pattern of small panels is to be produced.

Removal of metal by chemical action is another method in use today. Again, a substantial weight penalty is involved, as corners and radii do not work at the same rate as flat surfaces.

Two chipless (or plastic) methods have yielded good results and are capable of further development.

The extrusion of integrally stiffened strips and panels is already in wide use today. But billet size is limited on existing presses. Using cylindrical billets, widths of 24 in. have been produced. The use of rectangular billets would simplify the problem of flatness and would allow an increase of extruded width up to 30 or 32 in. if rectangular billet containers would be procured for the existing 8000-ton extrusion presses. The production of still wider integrally stiffened strips would be possible provided equipment of proper size would be available. Our investigations indicate the feasibility of 20,000- or even 40,000-ton special purpose extrusion presses for the production of very wide elongated shapes.

Extrusion, of course, gives configurations with only longitudinal reinforcements. Cross-ribbed panels cannot be produced (CONTINUED ON PAGE 61)



Making very large nozzles like this one economically remains a major problem. Hot-forming equipment that has been designed but not built would do the job.

Enter fiber-polymer structures

Deposited with great uniformity from water dispersions, materials of this kind may find a use in nose cones and wing leading edges

By Norman L. Greenman

ROGERS CORP., ROGERS, CONN.

THE PROBLEMS of re-entry bodies and boost-glide vehicles demand new thinking in terms of materials. In the area of nonmetals, fiber-polymer structures formed from water dispersions offer challenging opportunities, particularly where homogeneity and uniformity are necessary design conditions.

A great variety of fiber-polymer structures have been developed and produced by the uniform deposition of polymer particles on fibers suspended in water, or by beater-addition, as it is known in the papermaking industry. Typical of materials that can go into these structures is one of a series of reinforced Teflons, Duroid 5650, produced by Rogers especially for high-temperature applications.

One specific reason these structures are of interest is indicated by this statement by the Army: "Distortion-free signals to and from vehicles returning to the earth's atmosphere depend upon an extreme temperature-resistant material." The Army Ballistic Missile Agency (ABMA) has issued a contract for further development of Duroid 5650.

Studies at the Diamond Ordnance Fuze Labs (DOFL) and ABMA have shown that a material like Duroid 5650 can serve as a waveguide window at very high temperatures, such as those caused by re-entry. Two properties of Duroid 5650 are of major importance in the re-entry body antenna application. These are:

1. *Signal Uniformity.* Transmission of high frequency signals, as measured at DOFL, is uniform in any direction through the material. The dielectric constant of Duroid 5650 is 2.6, and it has a loss factor of about 0.0018. Both the dielectric constant and loss factor curves are flat from 25–280 C in the frequency range 10^7–10^{10} cycles.

2. *Ablation.* The ceramic fiber slows the rate of ablation, compared to that of pure Teflon, and the fiber-Teflon structure ablates evenly to produce a smooth surface. The ablation rate is about half that of pure Teflon when the fibers are oriented normal to the flow of hot gas. Because Teflon decomposes with no carbon deposit, burning, charring, or cracking, there is no signal distortion.

ABMA tests exposed Duroid 5650 for up to 11 sec to the direct flame of an 18,000-lb thrust engine rocket exhaust, 34 in. from the point of discharge. This produced a surface temperature of 1600 C. Although there was substantial ablation, the exposed surface appeared completely smooth, almost as though it had been machined.

Shaped Molding Preforms Possible

A facet of the beater-addition method deserving mention is the formation of shapes directly from the water dispersion to provide preforms ready for molding. This method gives homogeneous sheet material and a molded structure free of weak spots often encountered in large reinforced-plastic moldings. It should be possible, for example, to form and then mold complete radomes and wing leading edges by proper use of this technique.

Two limitations of beater-addition materials must be considered. First is the greater strength which can be obtained by the use of woven fabrics and oriented filaments. Where these strengths are necessary, beater-addition materials cannot now provide the answer.

Another, but less serious, drawback is the fact that polymers used in the process must be dispersible in water. Most polymers can either be dispersed or emulsified satisfactorily.

Despite these limitations, materials produced by the beater-addition method offer real opportunities in the design of specific products for demanding applications, as demonstrated by the Duroid 5600 series.

When the utmost in homogeneity and uniformity are necessary characteristics in fiber-polymer materials, products made from water dispersions certainly merit consideration.

Plastics for liquid rocket engines

Light, strong, relatively inert and heat resistant when reinforced, they have already found many uses and promise far more in the future as production techniques and quality control improve

By Ernest J. Zeilberger

ROCKETDYNE, A DIVISION OF NORTH AMERICAN AVIATION, INC., CANOGA PARK, CALIF.

Ernest J. Zeilberger is supervisor of nonmetallic materials in Rocketdyne's materials engineering group. After receiving a B.S. in chemistry from the University of California at Los Angeles, he became technical assistant to the research and development director of American Potash and Chemical Corp. He joined the materials and processes group of North American Aviation, Inc., in 1951, and moved to Rocketdyne in 1955. He is at present a member of NACA's subcommittee on lubrication and wear, and is chairman of the San Fernando Valley chapter of the Society of Aircraft Materials and Processes Engineers.

PLASTIC MATERIALS, already widely used in many different applications in today's liquid-propellant rocket engines, are a distinct class of polymerized organic chemicals that can be used either by themselves or in combination with reinforcing agents or fillers, such as glass, asbestos, metal powders or other inorganic particles. Having widely various properties, depending on molecular structure, plastics should not be looked upon as a panacea for rocket design problems, nor should they be regarded as suitable substitutes for all the older and more common materials. Rather, they should be viewed as materials with special properties and limitations.

Moreover, it must be borne in mind that the close tolerances common with metals cannot be kept with plastic parts. Tolerances vary depending on the method of fabrication of the particular part, i.e., molding, machining, forming or extruding. In general, the best tolerance that can be held is ±.001 in. and in some instances it may be as large as ±.005 in. A greater allowance for tolerance variations must be made on larger parts.

Offer Desirable Properties

What properties make plastics attractive for rocket engine applications? First and foremost, they are of low density, ranging from 2 lb/cu ft for the light foams to 140 lb/cu ft for heavily reinforced materials. This compares to a density of about 500 lb/cu ft for steel. Second, plastics are poor thermal conductors. This is advantageous because operating temperatures of a liquid-propellant engine may vary over a very short distance from —300 F (near cryogenic propellant) to combustion temperature, which may reach 6000 F.

And, last but not least, many are chemically inert, a valuable property since the propellants used in a liquid engine may include some of the most powerful oxidizers known.

Plastics can be divided into two general groups—thermoplastics and thermosetting materials. In general, in liquid-fuel engines, the thermoplastics are utilized for seals, electrical and thermal insulators, and gaskets. The thermosetting resins, generally reinforced, are used mainly for structural applications, flame shields, and thermal insulators.

By definition, a thermoplastic is a mono- or co-polymer in which molecules link end to end, forming long linear chains. This linkage

allows the polymer to soften at 200-350 F. A thermosetting plastic, on the other hand, polymerizes by crosslinking two or more monomers, thereby achieving a very rigid structure that doesn't soften when heated.

Let's look first at thermoplastics, some of their properties and applications. Probably the most widely used family of materials in this category are the fluorinated plastics. Kel-F and Teflon, the best-known commercial fluorinates, have found wide application in propellant tank liners and expulsion bags because of their chemical innertness. Teflon is often used as inner liner on flexible propellant lines, and is extremely useful as gasketing and packing in valves.

These two plastics are exceptionally inert. Almost any organic material in contact with lox or concentrated hydrogen peroxide will detonate if struck. Most require only a small impact (several foot-lb of force) to detonate. Teflon and Kel-F are the only two plastics known showing no impact sensitivity with lox.

The flexibility of Kef-F proves valuable. Lip seals for rotating and reciprocating shaft seals, and propellant gate-valve seals, must be flexible at temperatures from about —450 to 165 F, and require springback and dimensionable stability to seal against low and high pressure (5 to 600 psi). These exceptional properties can be achieved by special heat treatment of commercial Kel-F to control physical properties. This treatment is then checked by Rockwell hardness measurements for the precise quality control so necessary in this field.

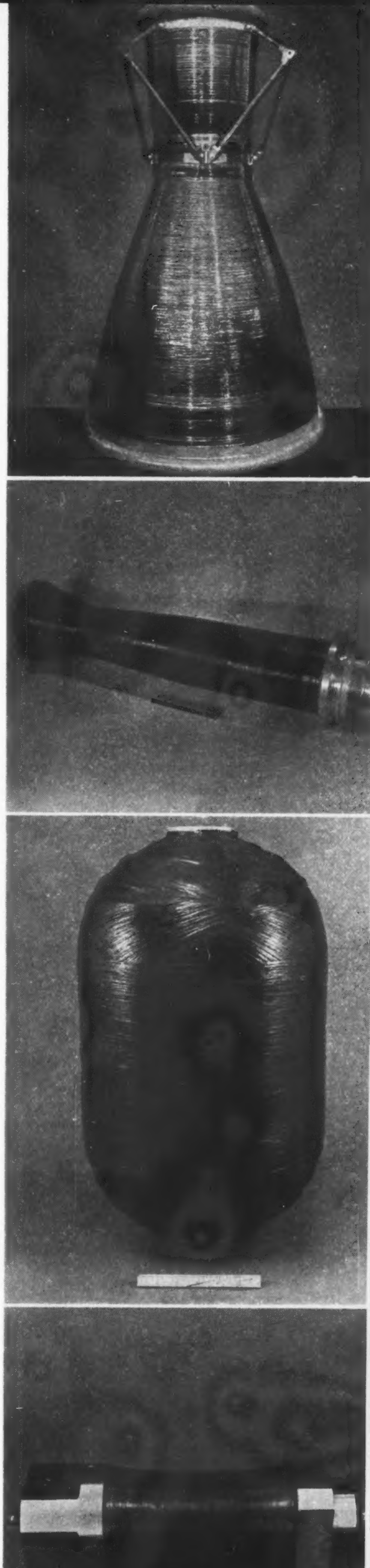
One drawback with Teflon, and in a smaller degree with Kel-F, is the property of cold flow. To overcome this problem, several filled materials are now available. The fillers used are mostly metal powders. Other additives, such as graphite or molybdenum disulphide, are sometimes added to the polymer to give it a good bearing surface.

Fillers Stabilize Cold-Flow, Expansion

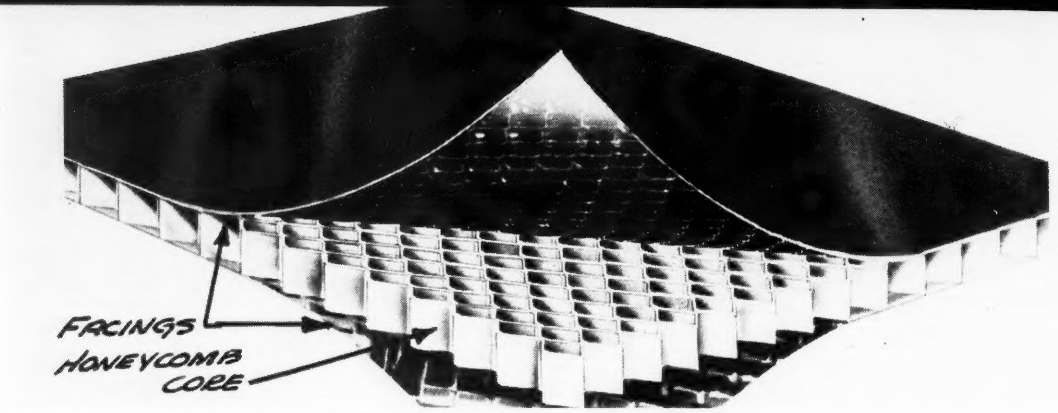
When designing thermoplastic parts for either low-or high-temperature service, one must bear in mind that the thermal coefficient of expansion of unfilled plastic materials is very high, about 10 times that of aluminum. Sometimes fillers, such as glass powder, asbestos, titanium dioxide, etc., can also reduce and stabilize expansion.

Mylar, a relatively new polyester film, is a thermosetting plastic, although possessing some thermoplastic properties. The strongest nonreinforced plastic known, Mylar has a tensile strength exceeding 20,000 psi at room temperature and 30,000 psi at —300 F. It is an extremely tough material which has found use in all types of diaphragm applications, from propellant tanks to pneumatic controls. Mylar is available only in thin films, which can be drawn by heat and vacuum into suitable shapes. Hemispheres with diameters as great as 22 in. have operated successfully as bladders for expelling lox.

Thermoplastics such as nylon, polyvinyl chloride and Teflon are used as insulation on rocket engine wiring (CONTINUED ON PAGE 76)



Of reinforced plastic structures, those made of epoxy resins and wound glass filaments have to date given the highest strengths. They have been used in combustion chambers and nozzles (top two pictures); air, nitrogen and helium bottles (third from top typical); and high-temperature ducts (bottom).



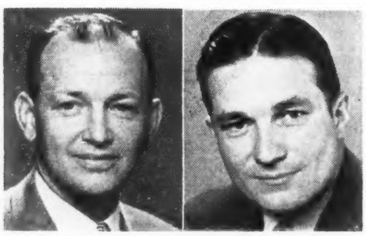
Typical brazed sandwich structure, showing facing and core.

High-temperature corrosion-resistant brazing

This process, introduced only eight years ago, already gives promise of producing complex but lightweight structures that are both strong and reliable at the temperatures encountered in hypervelocity flight

By John V. Long and George D. Cremer

SOLAR AIRCRAFT CO., SAN DIEGO, CALIF.


Long Cremer

John V. Long, director of Solar's research laboratory since 1951, has had wide experience in the fields of electronics, acoustics, geophysics, ceramics and metallurgy. At Solar, he has made important contributions to the development of high-temperature ceramic coatings for metals, aluminizing by ceramic methods, and all-metal honeycomb sandwich fabrication and inspection methods. A 1937 graduate of the U. of California at Los Angeles, he was a research engineer for Douglas and a geophysicist with Continental Oil Co. before joining Solar.

George D. Cremer is one of the nation's outstanding authorities in the fields of high-temperature brazing and stainless steel honeycomb structures. An MIT graduate, his experience in powder metallurgy research and production techniques includes positions as a staff member at Los Alamo Scientific Laboratory, 1943–1945; supervisor of body fabrication, NEPA project, Oak Ridge, 1947–1950; and consultant at Oak Ridge, 1950–1951. He has also been supervisor of research at Hardy Metallurgical Laboratory and consultant to many companies.

THE INGENUITY and resourcefulness of American industry have met the challenge of high-speed flight. Families of aircraft and missiles have been developed which fly at two to three times the speed of sound. Satellites circle the earth. The next step is space flight.

While these statements are basically true, we cannot close our eyes to the sobering knowledge that solutions to many of our present problems are not optimum. There is a need to increase the capability and reliability of available missiles. Advanced missiles and space craft will require new materials and unique manufacturing capabilities. Manufacturers will need creative imagination backed by a solid appreciation of natural laws, broad knowledge of prototype fabrication techniques and production processes, and a knack for successful experimentation.

Evolution of materials necessary for the space age should be rapid if materials development during and since WW II is any criterion. Adaptations and improvements of known processes will extend capabilities and provide additional solutions. And a relatively new process—high-temperature corrosion-resistant brazing—seems destined to play an important role in the fabrication of structures meeting the exacting demands of advanced missile and space vehicle designers.

High-temperature corrosion-resistant brazing has been defined as a metallurgical joining process wherein a molten filler metal with a melting point above 1600 F is used to join parts with a higher melting point than that of the filler. An additional essential is that diffusion between filler and base metal must occur.

This process was introduced less than eight years ago, but its technology has advanced so rapidly that even those closely associated with the field are amazed at its progress, and many herald it as the ultimate for precision joining of complex, lightweight, high-strength metal assemblies. Brazing will not replace established methods for all applications, but it offers advantages which permit fabrication of designs not attainable in any other manner.

What are these advantages? Some are suggested in this listing:

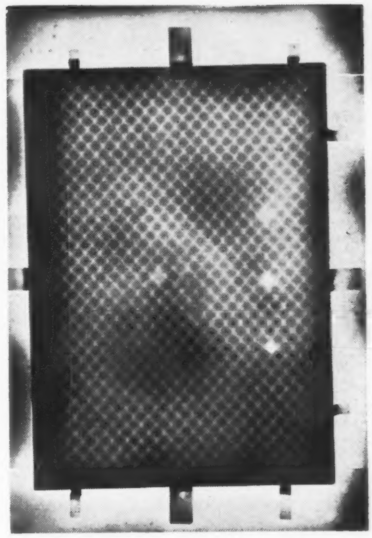
1. Ability to join complex, lightweight components with minimum weight increase.
2. Great flexibility in joining light and heavy sections and unlike materials in the same assembly.
3. High reliability of parts because of high joint strength and fatigue and impact resistance.
4. High strength at high temperatures.
5. More freedom from localized stresses.
6. Better distribution of thermal stresses.
7. Higher production rates and reduced production costs.

Now let's take a look at these advantages in terms of structures. Two important factors in the design of aircraft, missiles and space craft are strength-to-weight ratio and reliability. Present aircraft structural weight is about 30 per cent of gross takeoff weight. In missiles, the structure now amounts to about 15 per cent of takeoff weight. Since only about 10 per cent of the gross takeoff weight of space vehicles can be allowed for structure, structural reliability becomes of increasing importance because, as allowable weights decrease, safety factors approach a minimum and a more exacting job must be accomplished without excess material.

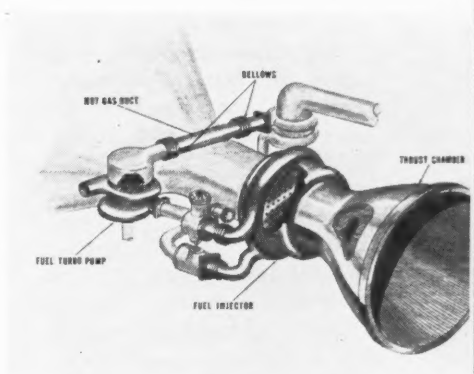
An analysis of structural requirements for missiles and space craft shows that the lightest structure must be made of materials with the highest ratio of ultimate strength to density at operating temperatures. In other words, thin, high-strength sheet must be used.

Thin sheets of such materials as stainless steel are strong in tension. A simple pull test shows that roughly 85,000 psi is required to cause failure of Type 321, and 20,000 psi of heat-treated 17-7PH stainless steel. On the other hand, thin sheets fold and buckle under very low compression. The compression problem disappears, however, when thin sheet metal can be combined with a honeycomb core and brazed into a sandwich structure. The core stabilizes the thin facings and provides a high degree of stiffness.

The photo on the opposite page (CONTINUED ON PAGE 86)

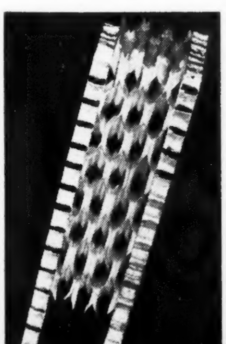


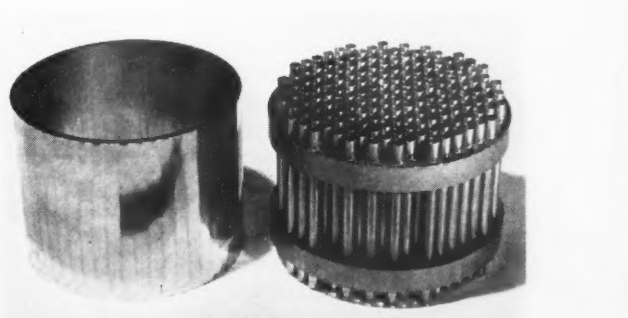
This experiment was designed to test thermal resistance of sandwich. Structure hangs in door of furnace. Inner facing of top diamond (right center), with outer facing removed, is at 1740 deg. Lighter diamond below it, with both facings removed, shows through to furnace at 2120 F. Outer facing is at about 1570 F.



Large liquid-propellant rocket engine, showing current brazing applications.

Some possible uses for brazed structures include (left) composite waffle-core fuel tanks or damage control walling; (center) precision control units and (right) marcel sandwich and tubing heat exchangers.

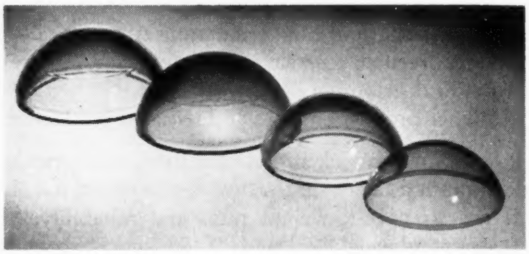




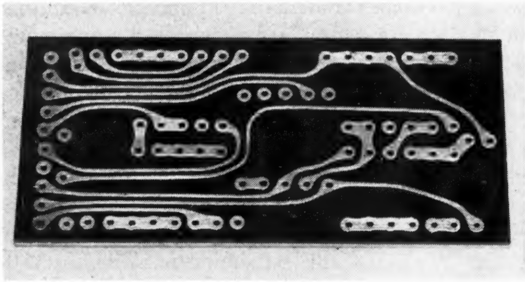
Glass gets hot

Missile industry takes another look at glass and ceramics as search for reliability and high performance picks up speed

Initial glassy blanks for Corning's Pyroceram radomes offer unusual advantage of visual inspection before heat treatment.



Leaching, firing and grinding bring $4^1/_2$ in. diam blank down to $3^5/_8$ in. diam missile window of 96 per cent silica glass and high IR transmission.



Circuit boards of Corning's Fotoceram, chemically machinable glass with flexural strength of 25,000 psi and dimensional stability up to 1000 F.

THE DRIVE for refined and reliable performance of vital missile components has sparked new interest in the properties of glass and benefits accruing from the way it can be formed.

Some glass will operate without serious deformation at temperatures up to 1800 F. New crystalline materials like Corning's Pyroceram can withstand short term peaks of 2200 F. Dense alumina ceramics will take even higher temperatures.

Combined with extremely stable dielectric properties and low expansion coefficients, this resistance to high temperatures and thermal shock makes glass and related ceramics serious contenders for such applications as radomes and high-reliability electronic components.

The physical properties of glass and related ceramics are better than many engineers suspect. Pyroceram, for example, is claimed to be harder than high-carbon steel, to have a strength-weight ratio comparable to aluminum, and to possess high resistance to corrosion and abrasion. Also, by compositional variations, it can be tailored to specific needs within a broad range of properties.

Glass and glass-ceramics also offer important benefits in forming. They can be automatically shaped by blowing, pressing, drawing or casting into complex, close tolerance parts. Purity and homogeneity can be carefully controlled in the mixing and melting of raw materials.

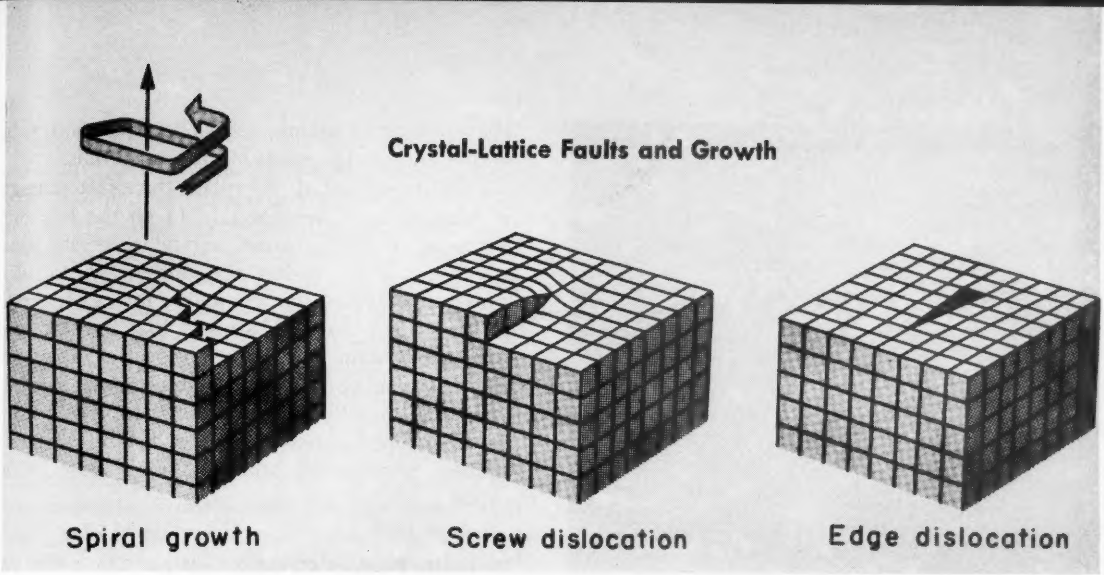
The missile industry's new look at glass and ceramics has brought an intensive revaluation of these materials. The pace of research in glass is quickening. Testing programs are providing the new and more detailed technical data needed by missile designers. At the same time, glass and ceramics engineers are learning to design their materials for maximum performance in missile applications.

In Corning's research laboratories, for instance, recently developed equipment permits measurement of thermal expansion curves up to 2500 F, while facilities for measuring thermal diffusivity are also being improved.

Attempts are being made to improve thermal emissivity and dielectric stability of glass and ceramics at high temperatures. In addition, thermal-shock resistance is being redefined in terms of rocket applications and techniques sought for more precise measurements.

Currently under development for missiles are such glass or ceramic products as ablating and sweat-cooled porous nose cones, infrared-radar domes, skin panels, leading edges, control surfaces, foamed insulation and liners for combustion chambers and nozzles.

Glass and ceramics engineers see stronger and more heat-resistant materials being developed in the not-too-distant future. Although they are comparative newcomers to the field of rocket-propelled flight, glass and ceramics are apparently here to stay.



A look at "whiskers"

Now only a laboratory curiosity, crystal filaments with the strength of atomic cohesion may be the key to light, strong space ship structures

George A. Hoffman

RAND CORP., SANTA MONICA, CALIF.

AT PRESENT, most efforts to obtain strong metal structures follow a metallurgical approach, such as alloying. Yet the highest strengths developed metallurgically give only a small fraction of the strength theoretically obtainable from the flawless cohesion of atoms in a metal. Strengths approaching those of atomic cohesion have, in fact, been demonstrated in fine crystal filaments commonly called "whiskers," which show the highest strength known to materials.

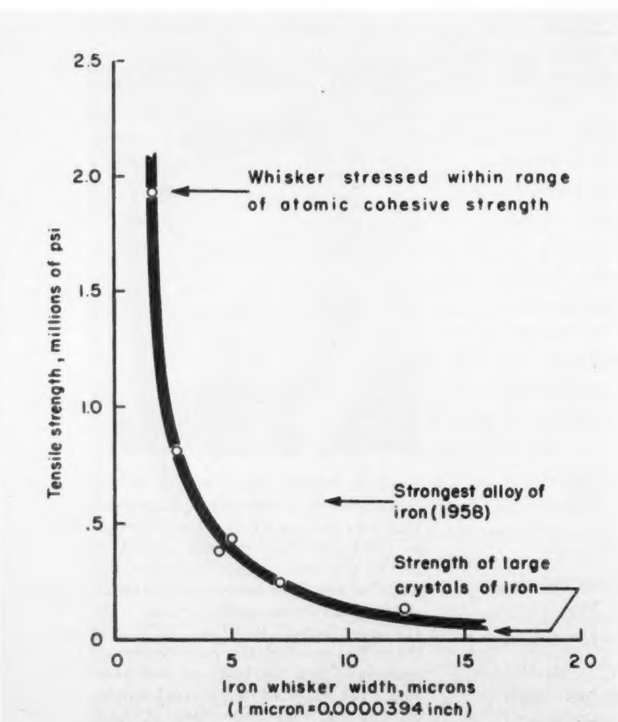
Assuming that they can be mass-produced in usable forms, whiskers offer a possibility of cutting conventional weight of tension-stressed structures as much as 80 per cent. Whiskers thus appear of great interest for astronautical vehicles, which will probably be designed largely as tension-loaded structures. Tank cabins, instrument enclosures, and the like are examples of components that will be tension-loaded by pressure in space vehicles.

Born in Milan, Italy, where he received his early education, George A. Hoffman took a Ph.D. from Harvard in 1950, and then became a lecturer at the University of California at Los Angeles, teaching courses in dynamics, statics, vibrations, and materials. Dr. Hoffman joined Rand in 1954, and there has worked on unconventional materials and methods of construction. He has authored several articles on the unusual properties of such metals, structures, and materials as beryllium, honeycomb and whiskers.

The Strength of Whiskers

The phenomenon of strength increase with decreasing crystal dimensions was observed as early as the 19th century. The phenomenon gained attention especially in the past decade, when crystal sizes were reduced beyond, say, $^1/_{10,000}$ of an inch. In the past three years, strength near that of atomic cohesion has been demonstrated both with whiskers of elements, such as carbon and iron, and compounds, such as oxides, halides, carbides, etc. Strength

Small, fine crystal filaments like these, grown in the laboratory, exhibit highest known material strengths. The graph below compares the measured strength of iron crystals and filaments in terms of width. Note how fine a crystal must be to gain very high tensile strength.



characteristic of atomic cohesion is also noticeable in thin films and platelets of many materials.

Theories advanced to explain the great strength of whiskers have been based (1) on the low incidence of edge dislocation, a type of crystal fault which can exist within the limited width of a whisker, or (2) on the restraining forces on crystal surfaces. It is usually assumed that the strongest whiskers contain only screw dislocation along the major axis and almost no edge dislocation. Furthermore, the growth mechanism of whisker tips has been explained in terms of screw dislocation by assuming spiral growth around a single screw dislocation.

Virtually Perfect Crystal Lattice

The figure on the preceding page depicts screw and edge dislocation and spiral growth. This fortuitous growth by orderly nucleation on the steps surrounding a screw dislocation almost eliminates weakening edge dislocations in whiskers and produces a virtually perfect crystal lattice with much of the strength of atomic cohesion.

Various theoretical calculations of atomic cohesion give an ultimate tensile stress anywhere from $^1/_{10}$ to $^1/_{40}$ of the modulus of elasticity. Tensile stress measured for certain whiskers (see table on opposite page) substantiates theory. Other notable properties of whiskers have been observed, or have been inferred, from the assumed absence of edge dislocations. These are:

1. Metallic whiskers exhibit a plastic range, while most compounds sustain elastic strains only up to failure.
2. The modulus of elasticity of a whisker may differ radically from the modulus of large polycrystalline amounts of the same material, and can range from a halving to a doubling of the polycrystalline modulus.
3. Creep has not been observed in whiskers below the normal recrystallization temperature, implying considerable strength retention even at temperatures close to the melting point.

The density/tensile strength ratio of whiskers is proportional to their density/modulus of elasticity ratio. This latter can serve as a criterion for choosing among whisker materials, a low value indicating superiority.

The table on the next page shows these properties for certain materials. The most promising whisker materials for room-temperature use seem to be the compound, boron carbide, and the metal, beryllium, which are competitive at ratios of 1.4 and 1.5 $\times 10^{-9}$ in.$^{-1}$ respectively.

To derive theoretically the relative weight of

equal-strength whiskers of various materials at various temperatures, we need know only density, modulus, and melting temperature and simple assumption as to modulus decrease with temperature.

The comparison of whisker materials at elevated temperatures is based on the assumption that strength deteriorates slowly at first but then rapidly between the recrystallization and melting temperatures. The recrystallization temperature for metals and some carbides is roughly proportional to the melting temperature in degrees Kelvin or Rankine.

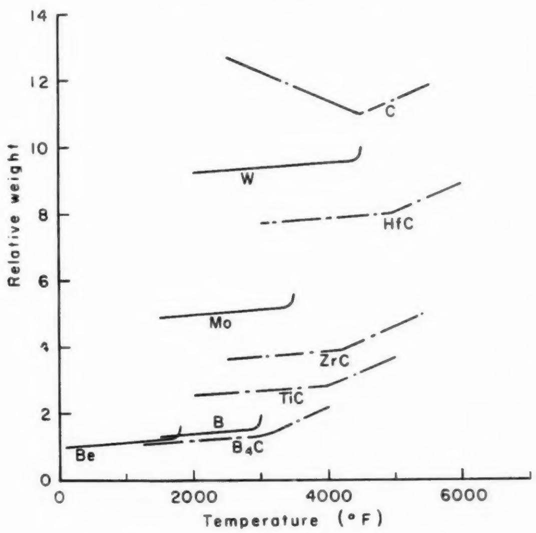
Giving a beryllium whisker a reference weight of unity, then, relative weights can be plotted for the least-weight metals and the least-weight carbides at high temperatures. The materials plotted in this manner in the figure below may be considered optimum within our present knowledge.

Structural Properties

The structural properties of hypothetical whisker materials can be calculated by assuming that:

1. Beryllium whiskers are the basic ingredient of the material, since they can sustain 3 per cent elastic strains.
2. Properties are derived at 70 F. Relative weights at higher temperatures can be obtained from the proportions indicated in the figure shown below. (CONTINUED ON PAGE 68)

Hypothetical Relative Weights of Optimum Whiskers



Note: The whiskers are of equal strength. The beryllium whisker is given a reference weight of unity.

Measured Tensile Stress of Some Whiskers

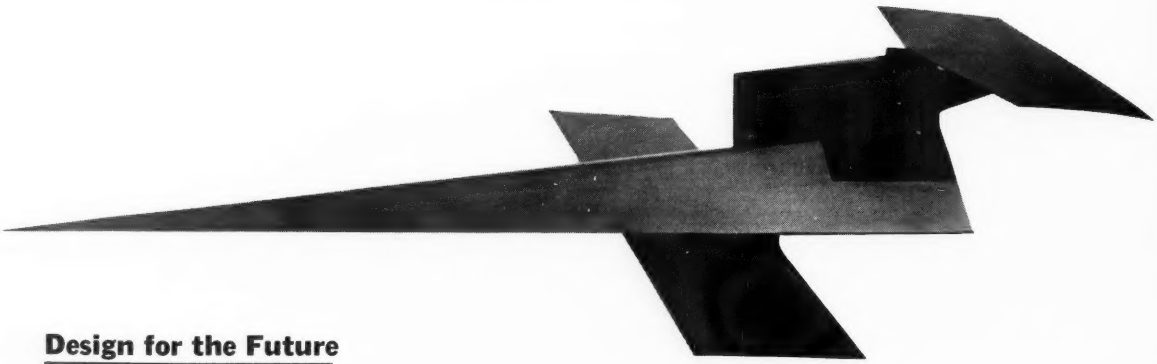
Material	Modulus of elasticity, psi	Ultimate tensile stress, psi	Stress/ modulus ratio
Silicon	23,000,000	550,000	1/42
Carbon	1,000,000	88,000	1/11
Iron	29,000,000	1,900,000	1/15
Silver	11,000,000	240,000	1/46
Copper	18,000,000	430,000	1/42
Quartz	11,000,000	600,000	1/18
Zinc	15,000,000	320,000	1/47
Cadmium	10,000,000	130,000	1/77
Sapphire	74,000,000	1,700,000	1/43

Selected Structural Properties of Materials

Material	Density, lb/in^3	Modulus of elasticity at 70 F, psi × 10^6	Density modulus of elasticity, 1/in. × 10^{-9}	Melting point, F
Beryllium	.066	44	1.50	2340
Boron	.083	50	1.66	4200
Magnesium	.066	6.5	10.2	1200
Aluminum	.100	10.6	9.4	1200
Silicon	.084	23	3.6	2600
Titanium	.170	16.7	10.2	3300
Chromium	.260	45	5.8	3400
Iron	.283	29	9.8	2800
Nickel	.322	31	10.4	2650
Zirconium	.231	12	19.2	3200
Molybdenum	.369	52	7.10	4800
Tungsten	.697	52	13.4	6170
Lead	.410	3.8	108	620
Beryllium oxide	.103	55	1.87	4580
Boron carbide	.091	65	1.40	4500
Magnesium oxide	.129	12	10.8	5070
Aluminum oxide	.137	52–74	2.6	3660
Silicon carbide	.115	70	1.6	4350
Titanium carbide	.178	51	3.5	5700
Zirconium carbide	.242	49	4.9	6400
Molybdenum carbide	.320	33	9.7	4870
Tantalum carbide	.523	42	12.5	7020
Tungsten carbide	.567	102.5	5.5	5030
Thorium oxide	.346	21	16.5	5900

Hypothetical Whisker Materials vs. Conventional Titanium

Material	Density, lb/in^3	Ultimate tensile stress, psi	Modulus of elasticity, psi
Whisker composite:			
Uniaxial tension	0.07	1,000,000	35,000,000
Biaxial tension	0.07	500,000	26,000,000
Potential structural metal: beryllium	0.067	50,000 to 100,000	44,000,000
Conventional metal, titanium	0.163	180,000	16,500,000



Design for the Future

High-speed gliding vehicles

Gliders of the type described here could prove valuable for recovering equipment from satellites and could also be used as man-carrying vehicles capable of operating in a range from subsonic to orbital speeds

By Karl M. Fuechsel

WRIGHT AIR DEVELOPMENT CENTER, WRIGHT-PATTERSON AFB, OHIO

Karl M. Fuechsel is a task scientist for Wright Air Development Center's Aeronautical Research Laboratory. A mechanical engineer educated at the Technical University of Berlin, he worked in Germany on gas generators for motor vehicles, on superchargers and on the layout of jet engines. In this country, he has worked at WADC on the design of propjets, research test equipment, aerodynamics of long-range guided missiles, and the application of nuclear propulsion to high-speed flight vehicles.

GLIDING test vehicles are of interest in two main areas. First, a glider might prove to be a practical vehicle for recovering equipment from earth satellites and, second, it should also be possible, within the span of a normal development program of about two years, to produce a man-carrying glider capable of operating in a range from subsonic to satellite speeds.

How one would go about designing such a vehicle would depend to a great degree on how soon it would be needed. For the first purpose mentioned above, it would probably be best to build the glider without moving parts for fixed-stick flight. Additional time would permit development of an automatic guidance system or turning it into a manned vehicle.

With these possible uses in view, let us now examine the glider as an experimental device to gain experience with the gliding mode of flight. Assuming reliability as an immediate goal, conventional aircraft design is chosen for the initial glider shape, although design improvements could be made later on.

Following conventional aircraft design, the glider, two versions of which are illustrated on page 35, would have straight, very thin wings, with or without taper, and a medium aspect ratio (3 to 4). The wings would carry 70–80 per cent of the total weight, the remaining lift coming from the body and a horizontal tail.

The tail, above the body line and through the center of gravity, should give sufficient restoring moment for fixed-stick flight from supersonic to satellite speeds, as well as at subsonic speeds when

it may be necessary to land with stick control. The tail, turning as one piece, as in present day fighter aircraft, would ride on a vertical stabilizer, giving zero static lateral stability at the most unfavorable (probably the highest) speed.

A one-piece turnable rudder would ride below the body axis and through the CG. This form of rudder, introduced in 1908 in the Antoinette monoplane, avoids adverse roll when deflected, a distinct advantage for any phase of glider flight.

The body would be wedge-shaped, with one flat surface and a blunt base. Guided gliders might have a flat bottom; stick-fixed gliders might have a flat top. The dimensions of the flat-bottomed model shown on this page refer to a full-scale manned gliding vehicle. The smallest free-flight model containing guidance could be $^1/_{20}$ this size, or $^1/_{10}$ this size if air-conditioning equipment had to be included for very long glides.

What will lift and drag, aerodynamic heating, and stability of this gliding vehicle be like?

Aerodynamic Values Calculated

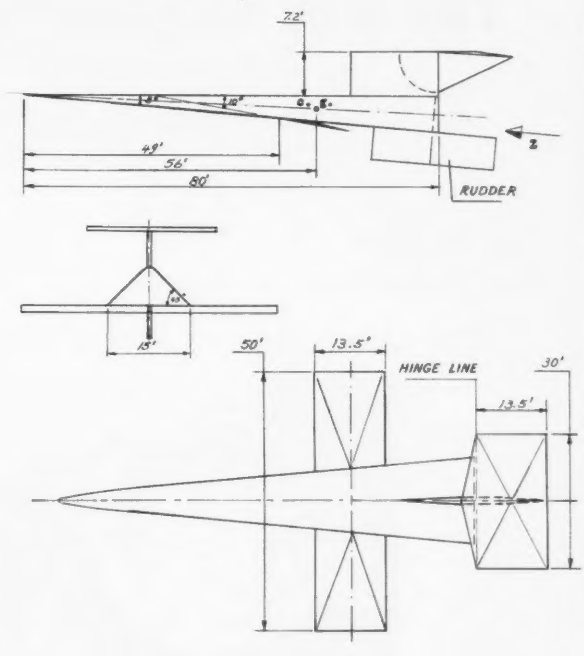
Lift and drag of the flat-bottomed model have been calculated by compression and expansion linearized theory for Mach numbers from 1.5 to 22, and there are also available extensive wind tunnel measurements of a similar model at Mach 1.2 that agree fairly well with actual flight data on a flat-bottomed model. Calculated values agree very well with those of other authors for similar configurations at hypersonic speeds.

Regarding only aerodynamic forces, the maximum lift-drag ratio (L/D_{max}) varies between 4.5 and 4.0 over a Mach number range of 1.0 to 15, and decreases to 3.2 at Mach 20. The L/D_{max} is considered in terms of both angle of attack (W) and altitude. This drop is of little concern, because a glider at this speed would, we may assume, be in orbit and derive "lift" from centrifugal forces. The corresponding angle of attack varies between 6.5 and 4.0 (angle of attack being zero when lift equals zero).

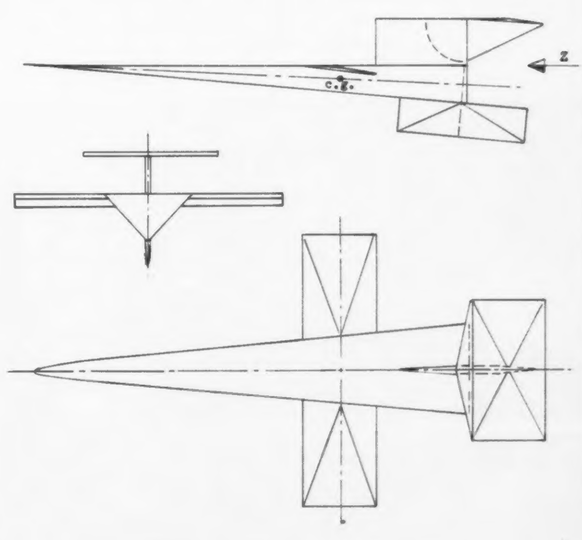
Finally, we can look at the ratio of constant wing loading to angle of attack as a function of altitude and Mach number. Wing loading is defined by the total momentary weight of the glider, measured at zero speed, divided by the wing area. The flat-bottomed vehicle with wing loading of 10 lb/sq ft would have to start at an altitude of 240,000 ft with a speed of Mach 22 to glide halfway around the world, and at 180,000 ft and a speed of Mach 15 to coast one quarter of the way around the earth.

In such flights, the glider will travel in the atmosphere two-thirds of the time at Mach numbers between 12 and 8. It will get (CONTINUED ON PAGE 72)

Glider Configurations



Flat-Bottomed



Flat-Topped

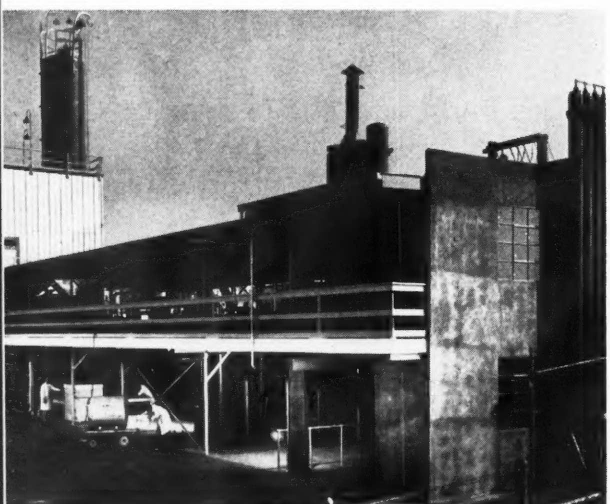
The way to missile reliability

Bringing the many components of a weapon system together for rigorous testing in one "single-roof" facility can help turn the trick

By Eric Burgess

ASTRONAUTICS FIELD CORRESPONDENT

Valve interior, contaminated by foreign matter in helium, demonstrates why lab testing is needed for both components and subsidiary equipment.



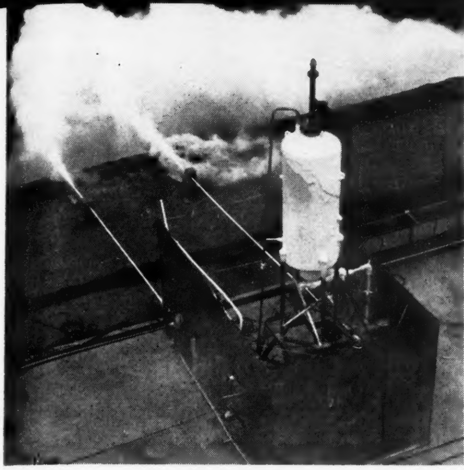
Part of the Wyle Laboratories single-roof facility, showing the heat exchanger, helium storage tank, centrifuge, and control tower.

A DECADE of designing, testing and building guided missiles has made it clear that they require complete, and not partial, integration of engineering. There is, as a case in point, no longer any question that reliable missile systems need components designed and tested specifically for missiles, and not for automobiles, airplanes, home radios, etc.

This applies both to components for the missile proper and to the equally, and sometimes even more, complex subsidiary equipment for storing, handling, and launching it. Producing ground equipment for servicing and checking out a large missile and its launching system has, in particular, become a major task. There must be regular functional checks of the whole missile-launcher system without using propellants in a hot run. These checks show proper continuity of electrical connections, functioning of hydraulic and pneumatic valves, propellant tank pressurization, operation of the guidance and control system, etc.

This check of the missile and launching system with all but live propellants is in effect a double check on component functioning, and proof that previous functional and quality-control testing of the components has served its purpose.

Even when components are designed for a missile and produced to the missile designer's specifications, it must be remembered that they flow from literally hundreds of companies, large and small, to the manager or prime contractor for a missile system. These companies range in size from pint-sized manufacturers of one or two electronic specialties to the line divisions of major manufacturers who may be turning out all or some major part of a subsystem. All funnel to the missile manager, who must join them and make one very elaborate piece of work that will function in a matter of minutes without a hitch.



Ballistic missile component undergoes lox run in cryogenics facility. Test simulates actual use conditions of the component.

Largest of its kind, Wyle's 20 million Btu/hr heat exchanger at Norco, Calif., converts lox or nitrogen to gaseous form at high flow rates characteristic of maximum boiloff in large missiles.

The responsibility for the proper functioning of components and subsystems rests with the manager. He will gain some idea as to the quality of components by checking the nominal specifications for them. Even if they meet such specifications, however, components will never have been tested in the missile itself and will probably not have been tested in a setup simulating missile dynamics.

Components Change Before Used

The component may even have been produced before the rest of the missile passed the stage of initial development—that is, before the whole missile has been put together and successfully flight-tested. It may sit in a warehouse for months, waiting an appropriate time to join the development cycle. The manufacturer of this component, on the other hand, may have raced to deliver it and may have had no chance to determine its shelf life. This task devolves upon the manager. It could also be that, between the time the manufacturer delivers his component and the time it comes to use, the criteria on which he based his own inspection will of necessity have been changed by the missile manager.

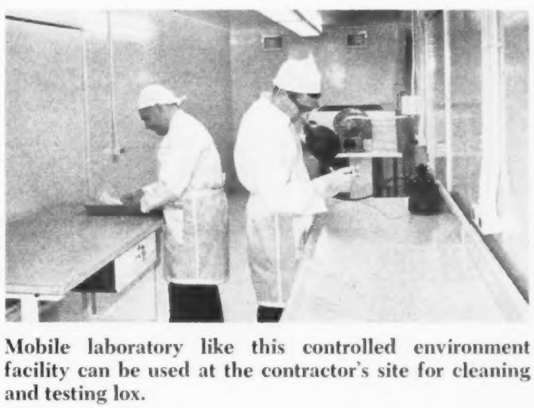
Finally, there is the cost of elaborate and specialized testing equipment to contend with. Not every component maker can finance a fully rated vibration-testing machine, low temperature facility, etc. This is another reason the missile manager may have to rely on nominal specifications, and may even find himself short of means to carry out all the component testing he would like to do.

The manager must consequently either test components for proper functioning and reliability himself or find someone to do the job for him. If the manager feels he could operate most efficiently by testing and manipulating the larger systems, he may look for a specialist to do all of his component and subsystem testing and to verify the adequacy of components against standards he specifies.

This approach, introduced only recently as a consequence of a study of the missile business and its future needs, has given rise to a concept known as "single-roof" testing.

A proponent of this approach, and one putting it into practice, is Wyle Laboratories, El Segundo, Calif., which specializes in aircraft and missile component testing. Wyle's facilities, working something like the cooperative wind tunnels, are used by prime contractors who want equipment delivered to them from a number of subcontractors to be independently checked against stipulated standards. Wyle's central testing laboratory is designed to simplify contracting, scheduling, liaison, and inspection while delivering products ready for use by the prime contractor or an associated military service.

The company realized that the five most important areas in which need for (CONTINUED ON PAGE 66)



Mobile laboratory like this controlled environment facility can be used at the contractor's site for cleaning and testing lox.

Pictorial highlights of the Los Angeles meeting

Registration desks were kept busy all day long by record attendance of more than 2700.

Left to right, banquet speaker Lee DuBridge, president of Cal Tech; ARS President George P. Sutton; and Rear Adm. John E. Clark, ARPA deputy director and one of the luncheon speakers, chat at Aerojet reception.

Chandler Ross of Aerojet and Antoni K. Oppenheim of the U. of California enjoy a good laugh at the reception.

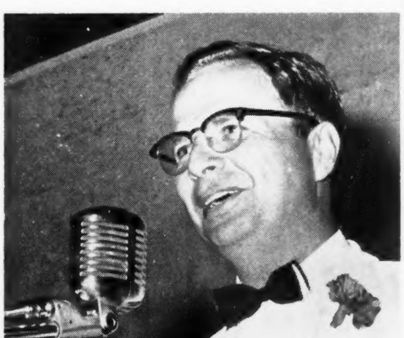
Left to right, Kurt Stehling of NRL, William L. Gore and Chandler Ross of Aerojet, A. K. Oppenheim and James M. Carter, Chemalco, Inc.

Wheels and their ladies. In the usual order, the George P. Suttons; G. Daniel Brewer, Space Technology Laboratories, president of the Southern California Section, and his wife; and William J. Cecka of Rocketdyne, vice-president of the SoCal Section, and his wife.

Left to right, Lee DuBridge; Howard S. Seifert of Space Technology Laboratories, ARS National Program Chairman; Rear Adm. John E. Clark; and Charles A. Knight of Space Technology Laboratories, general chairman of the meeting, chat at banquet head table.

Brig. Gen. William R. Large of SAC, William H. Pickering of JPL, and George Sutton at banquet head table.

Left to right, luncheon speaker Norris Bradbury, director of the Los Alamos Scientific Lab; Lee DuBridge; Andrew F. Charwat of UCLA, coordinator of the first Western Regional Student Conference, held during the meeting; and Lt. Col. David G. Simons, chief, Aero Medical Field Lab, Holloman AFB, and chairman of the ARS Human Factors Committee.

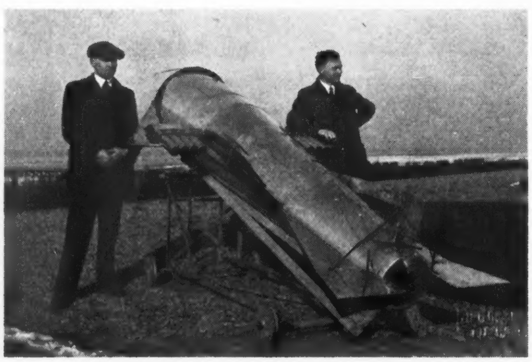


Left, George Sutton in toastmaster role and, below left, Lee DuBridge, banquet speaker.

Astronautics Editor Irwin Hersey discussing ARPA with Rear Adm. John E. Clark.

Top (left), note carried in 1932 experiment signed by the experimenter and (right) cover flown in first night flight at Hasselfelde, Germany, in 1933. Bottom (left), cover from 1935 Indian experiment and (right) cover flown in Mexico-U.S. flight supervised by Robert H. Goddard in 1936.

Rocket mail history—in stamps



Previously unpublished photos show rockets used in G. Zucker experiments at Hasselfelde in 1933 (above) and Santis, Switzerland, in 1935 (below).

A REMARKABLE collection of rocket mail stamps, covers, photographs and related material recently came into the hands of Stampazine, a New York City philatelic center.

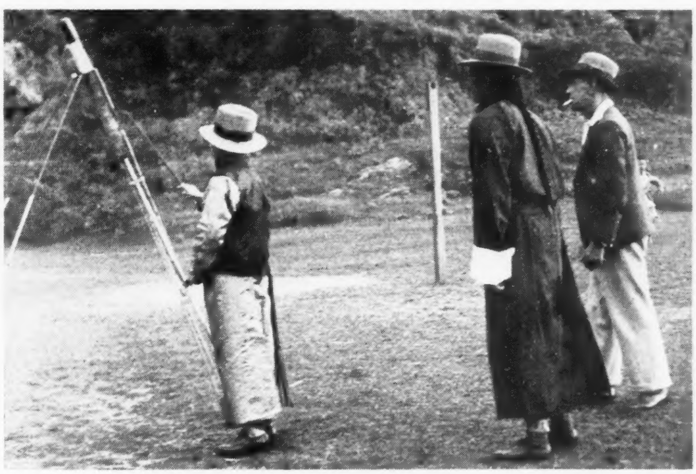
Consisting of eight large format, handsomely bound volumes, the collection, which has since been sold to a private collector, was assembled over a period of years by the late B. T. Ackroyd of Yorkshire, England. It represents almost a complete history of rocket mail, from its earliest beginnings, in the late 1920's and early 1930's, to 1955, and covers some 17 countries.

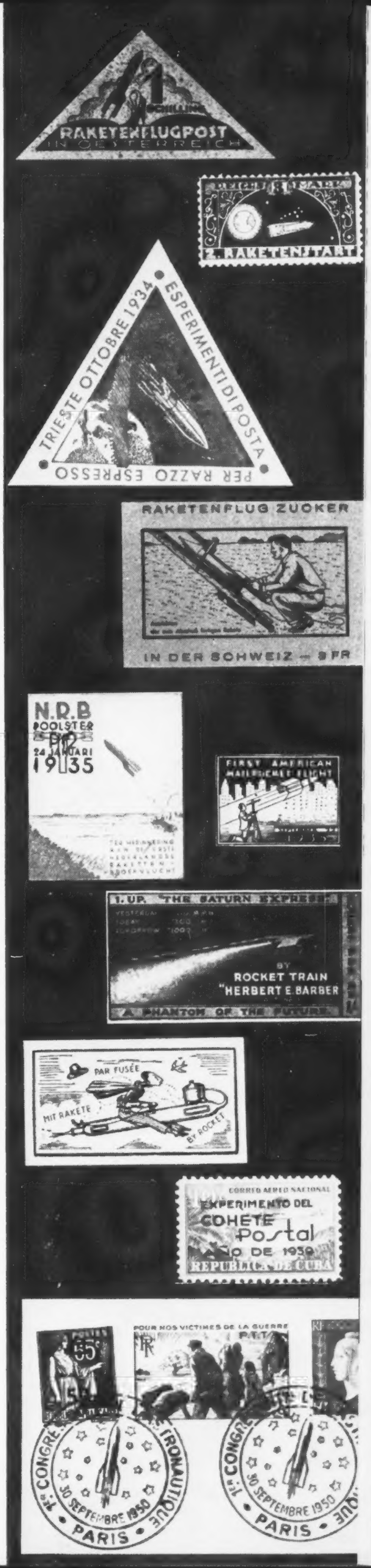
In addition to a fascinating and voluminous collection of hitherto unpublished photographs of early rocket mail experiments and experimenters throughout the world, the collection includes such curiosities as propaganda leaflets dropped over England and France by German V-1 and V-2 missiles; Communist anti-Adenauer leaflets delivered via rocket from East to West Germany; the earliest rocket mail stamps, vignettes, cachets and covers, many of the latter containing personal letters written by the experimenters; a holograph letter by William Congreve, as well as a letter from his wife telling of his rocket experiments; an original Golightly steam rocket lithograph; an article from a London newspaper in 1855 dealing with war rockets; and stamps and covers issued in commemoration of, or to raise funds for, almost every major rocket mail firing of the last 30 years.

Value of the collection is set at about $35,000.

Experimenters ready rocket mail plane designed by Willy Ley for flight at Greenwood Lake in 1936 (left). At right, Ley, in protective suit, sets fuse for what turned out to be unsuccessful firing.

This Indian rocket flown in 1935 (above) carried live cock and hen, plus 189 messages, in successful flight. Photo below indicates everyone was interested in such experiments.





AROUND THE WORLD: Top to bottom, Austrian rocket stamp; German stamp marking first night firing; Italian stamp; essay for Swiss stamp; Dutch stamp and stamp marking first successful U.S. rocket mail flight in 1935; Indian "rocket train" stamp; British vignette; first official rocket stamp, issued by Cuba in 1939; and cancellation marking first IAF Congress in Paris in 1950.

Ed Kurczewski of RMI demonstrates jumps made possible by the belt.

Military jumping jacks?

Jump belt may provide future assault troops with rocket-assisted takeoff

REACTION MOTORS Division of Thiokol Chemical Corp. recently demonstrated a novel "jump belt" which will give the long neglected foot soldier rocket-assisted takeoff.

While details of the belt's operation have not as yet been announced, the photographs on this page indicate that it consists of solid-propellant gas generator units linked for firing singly or in combination through a dual-nozzle yoke that rides across the hips. The jump belt has enabled a Reaction Motors daredevil to leap as much as 20 ft while carrying a 50-lb pack.

RMI anticipates that the foot soldier of the future will be equipped with a jump belt of this type at his waist under a field pack. The small nozzles apparently do not interfere with normal movement, and the pack-and-belt combination is reportedly lighter and smaller than the combat pack assault troops usually carry.

The company claims the belt would enable assault troops to cover vulnerable areas in a minimum amount of time. It could be used for jump landings from small boats; for attacks against pillboxes, carried out by leaping over them and directing flamethrowers against poorly protected parts of the pillbox; and for needed assistance in crossing difficult terrain, such as muddy river banks, thick hedges, barbed wire, etc.

The belt, now under consideration by the Army, will give lazy soldiers something new to worry about. They'll have to be careful or a topkick may send them flying by remote control ignition.

Photo at left shows how the belt would be worn in combat. Close-up above shows how jet is directed away from body by harness.

Missile market

BY ROBERT H. KENMORE

WHILE market analysts quibbled over whether stock market action was characteristic of a major secondary recovery movement in a bear market or the entry into a new bull cycle, the missile index reached a new all-time high.

As indicated on the chart at right, the index topped the previous high of 628 reached in August of last year. While this action is indeed impressive, analysis will show that unbounded enthusiasm for missile securities as a whole is unwarranted. A lot of divergent activity occurred in the eleven months separating the two similar peaks. As a matter of fact, half of the companies which make up the index showed changes in market value *in excess of 20 per cent.*

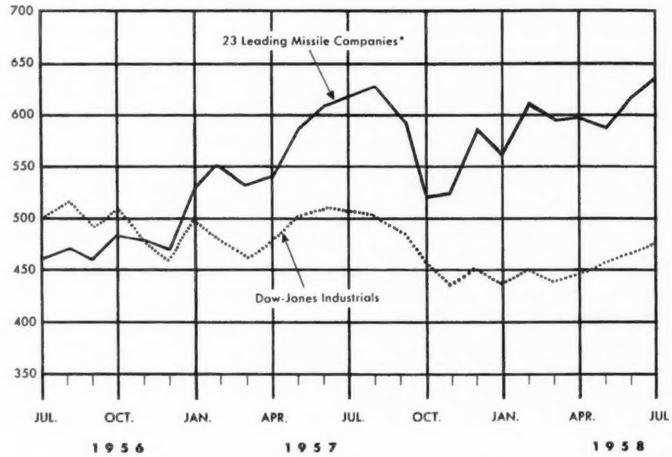
Seven securities showed significant gains: Raytheon, up 49 per cent; Chance Vought, 40; Emerson Electric, 36; North American Aviation, 30; Lockheed, 27; American Bosch Arma, 23; Thiokol, 22.

Four companies, on the other hand, had major declines: Thompson Products, down 32 per cent; General Precision Equipment, 28; Sperry Rand, 22; Douglas, 20.

The above lists indicate no clear trend for any one section of the industry—both aircraft and electronics are represented on either side of the fence. In addition, while gains seem to outweigh losses, only three of the seven which improved (Raytheon, Emerson Electric and Thiokol) represent true advances to new, higher levels. The other four were only regaining some previous setbacks. The important conclusion is that "volatile" and "selectivity" are still the watchwords of investors in the missile industry.

Market action can be dramatic but short-lived and it takes a lot of courage to resist the temptation of short-term trading. A good example of this, by the way, was recently provided by Marvin Raphael's Chromalloy Corp. mentioned in last month's column. In a period of about two weeks during June, Chromalloy common rose from 15 to 26 in heavy trading on the American Stock Exchange before profit taking set in. What to do with the stock at that point depends on the analysis made of the inherent real values in the situation. If these are sound it is very likely that the stock will continue to rise further in future months. (This is the kind of action that Thiokol Chemical's sound corporate growth has imparted to its stock, which has steadily risen from 8 to 42 in the last three years.) On the other hand, if this dramatic rise is more psychological than anything else it was probably better never to have bought the stock at all.

THE MARKET AT A GLANCE



*Index compiled June, 1955

	July 1958	June 1958	% Change	July 1957	% Change
Dow-Jones Industrials	475	463	+2.6	503	−5.6
23 Missile Companies	638	620	+2.9	621	+2.9

The part-time investor cannot afford to compete with the professional on the roller-coaster ride of short-term market swings. Over the long term, he will inevitably find that he has bought more stocks at 26 that went to 15 in short order than the other way.

In the same vein, the average investor should never be in a hurry to put his idle cash to work. At present, for instance, when many people are saying that we are on the threshold of a new bull market the temptation is great to get on the bandwagon as fast as possible. It is far wiser, we feel, to wait for positive confirmation of a new long-term upward trend.

No one should try to squeeze the last drop of profit out of an investment, and buying at the bottom and selling at the top is an illusionary feat whose attempt can cost the investor a lot of money. If indeed the market is on the threshold of a new bull movement, paying 10 per cent more for a security will still leave plenty of room for future profits. It is much more likely at the present that the security might well be bought for 20 per cent less, and it is a truism that no investment should carry anywhere near as much risk on the down side as it does profit potential.

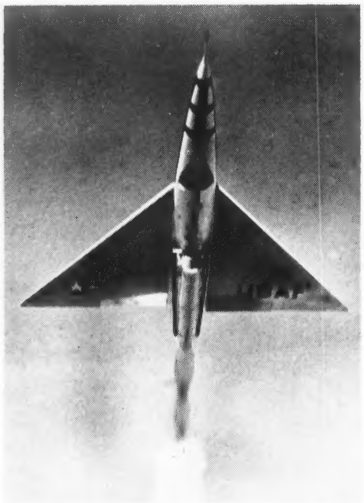
Individual corporate developments and estimates of future earning power should still determine what stocks are selected. Rumors, tips, dramatic "hot air" runups, bull market psychology or a friend in management have still never been proved a sound basis for long-term capital appreciation in spite of the few boastful claims one hears to the contrary.

A further danger in the choice of investments is the tendency to buy shares on spot news announcements of a bullish nature. A big contract, an increased dividend, an announcement of dramatically higher earnings for the year just ended are none of them sufficient reason for an immediate purchase of a stock "at the market."

The "news" is usually being discounted in the market place far in advance of its announcement and the present market price already contains in it the factor of the expected news. As a result the stock very often will go down on the announcement and the

(CONTINUED ON PAGE 82)

Goose on the Wing



Air Force's diversionary Goose missile is shown in flight after launching from Cape Canaveral in first photo of missile released by DOD.

New Era

(CONTINUED FROM PAGE 21)

reinforced plastics, and ceramics. These developments for ballistic reentry bodies will provide a broad background for orbital re-entry vehicles.

Likewise, the development of graphite, ceramics, and coated molybdenum as *heat-sustaining* materials holds considerable promise for the steady-state heating environment of leading edge structures of boost-glide vehicles. Another approach may be the development of slowly ablating materials for use on leading edge structures. In all cases, serious consideration should be given to any significant weight advantage accruing through use of limited lifetime, replaceable leading edges.

Structures governed primarily by thermal rather than load-carrying requirements have material requirements which are stringent in terms of heat absorption or heat sustaining characteristics and relatively minor in terms of mechanical strength.

But, when viewing the primary load-carrying structure of boost-glide vehicles, material requirements include both major strength and thermal characteristics. Thus the problem is considerably different than for the structures discussed previously, and in all probability the really successful solutions will involve extensive material-structural design.

Before considering the various approaches to the design of a 2000 F load-carrying structure, let us consider the roles performed by the outer structure of an airframe. In general, the covering provides both contouring and load carrying functions. Thus, minimum weight considerations for compression surfaces often lead to optimum stress levels considerably below the yield strength. In hypersonic vehicles, the skin provides a thermal-shielding function, as well as contouring and load-carrying functions.

The most direct approach to the design of primary structure is the use of heat-sustaining materials. In this case, the three functions are satisfied by the temperature-resistant skin. Thermal shielding is provided by a high emissivity coating which permits radiation of a major portion of the heat, thus effectively cooling the structure by "radiation cooling."

Because of the greatly deteriorated weight-strength characteristics of materials in the 1200 to 2000 F range, the use of the heat-sustaining approach necessitates a low load-carrying function for the skin. To some extent, this is already true, since glide-type vehicles necessarily operate at low wing loadings. In addition, by use of an internal supporting structure, the surface load may be reduced further.

Thus the strength requirements for the heat-resistant structure can be reduced by proper design to the point where the skin effectively provides only contouring and thermal shielding functions. Contouring requirements provide certain minimum stiffness criteria to avoid panel flutter. This approach, in effect, results in material requirements similar to those for the leading edge structure.

Thermal Shielding Helps

An alternate approach to the design of primary structure for boost-glide vehicles is to employ thermal protection techniques for the load-carrying structure. In this manner thermal shielding and contouring functions are separated from the load-carrying function.

It is apparent from weight-strength considerations that 1000 to 1200 F is the current upper limit of equilibrium temperatures that can be met with the use of heat-sustaining materials in relatively efficient load-carrying structures. To go beyond 1200 F with current materials introduces a prohibitive weight penalty as compared to a 7075-T6 aluminum-alloy primary structure at room temperature. Beyond 1000 F, and in all probability at considerably lower equilibrium temperatures, thermal protection of the load-carrying structure by various material-design techniques appears to offer an attractive design approach.

Thermal protection of primary airframe structures appears very efficient in terms of complete system weight. Operation of the load-carrying structure at relatively low temperatures permits the use of low density alloys, avoids a host of materials problems associated with, for example, high temperature seals, lubricants, and elastomers; and does not require special cooling for the pilot, fuel, and equipment.

A promising development for hypersonic gliders consists of an external high temperature radiation shield which radiates a major portion of the heat flux absorbed from the boundary layer. A moderate thickness of fibrous insulation is placed adjacent to this radiation shield. The small portion of the heat flux transmitted through this low density insulation is removed by a cooling system attached to the primary structure. The amount of coolant required to keep the interior below 200 F is sufficiently small so that low density aluminum or magnesium alloys can be used for the load-carrying structure.

With this approach, it appears feasible to construct a relatively efficient composite structure which can be subjected to external equilibrium temperatures up to 2000 F. The major materials requirements involved in this thermal-protection technique up to 2000 F, and beyond, are concerned with the radiation shield, and are of a similar nature to the leading edge problem.

It is the intent of this rather brief article to sketch an introductory background to the relation between the hypersonic environment and the material-design aspects of hypersonic vehicles. It is evident that we have entered an era which places tremendous emphasis on materials-design technology.

Development of new forms of construction and fabrication is essential for the effective utilization of materials. Development of materials themselves, must be guided by more precise definitions of the environment and design conditions. This realization is slowly taking place, with the result that a two-way bridge of understanding and sharing of problems is developing between structures and materials-oriented engineers.

NSF Fellowships Open

National Science Foundation has announced that it will accept applications for senior postdoctoral and science faculty fellowships through Oct. 15, and will make the awards in December hereafter, instead of biannually, as in previous years.

ARS news

Semi-Annual Meeting Draws Record Attendance of 2700

When a meeting gets so big that larger rooms have to be made available by the hotel management to take care of the crowds, it's a pretty good indication that the event was a howling success—and that's just what happened at the ARS Semi-Annual Meeting at the Hotel Statler in Los Angeles June 9–12.

The attractive program, the timing of the meeting and its location in the heart of the "rocket belt" all played a part in the turnout of more than 2700 people for the four-day event—by far the largest attendance ever at an ARS meeting. This total included 1528 technical registrants, 400 exhibitor personnel who manned the 70 booths at the highly successful ARS Astronautical Exposition held in conjunction with the meeting, and some 800 visitors to the exhibits.

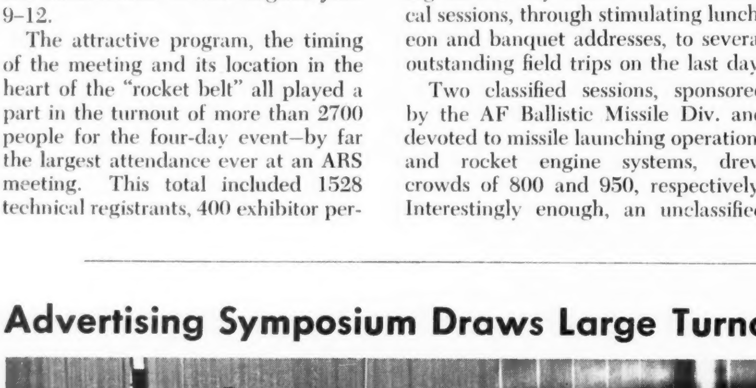
Highlights of the meeting were almost too numerous to mention, ranging all the way from a dozen technical sessions, through stimulating luncheon and banquet addresses, to several outstanding field trips on the last day.

Two classified sessions, sponsored by the AF Ballistic Missile Div. and devoted to missile launching operations and rocket engine systems, drew crowds of 800 and 950, respectively. Interestingly enough, an unclassified session on flight dynamics of space vehicles, held at the same time as one of the classified sessions, also drew "standing room only" attendance.

Other standout technical sessions dealt with the IGY program, test instrumentation, management of experimental engineering projects, fluid physics, handling and testing of liquid-rocket and ramjet engines, operations research and experimental engineering, space vehicle guidance and bio-satellites. A highlight of the latter was the showing of movies of Soviet rocket experiments with dogs and the training of Laika for her ride in Sputnik II.

An innovation at the meeting was

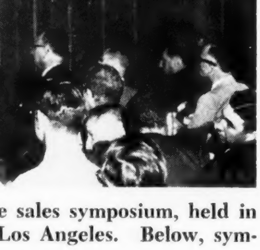
Advertising Symposium Draws Large Turnout at L.A. Meeting



ARS Executive Secretary James J. Harford opens the sales symposium, held in conjunction with the ARS Semi-Annual Meeting in Los Angeles. Below, symposium speakers.

George P. Sutton

Col. L. F. Ayres



William C. Strang

M. W. Hunter

Ronald Smelt

William C. House

The first in a series of special symposiums, designed to acquaint advertising and sales executives of suppliers to the astronautical industry with present and future needs of prime contractors, drew a large and enthusiastic audience at the ARS Semi-Annual Meeting in Los Angeles.

Sponsored by ASTRONAUTICS, the symposium took as its theme "What the Astronautical Systems Designers Want to Know About Your Product."

James J. Harford, ARS Executive Secretary, acted as chairman. Symposium participants and topics covered were: George P. Sutton, manager of advance design, Rocketdyne, and ARS President, "Space Flight and the Systems Designer"; William C. House, manager, Systems Div., Aerojet, "The Propulsion System Designer"; William C. Strang, staff engineer, Convair-Pomona, "The Guidance System Designer"; M. W. Hunter, chief missiles design engineer, Douglas, "The Vehicle System Designer"; Col. Langdon F. Ayres, Chief, Propulsion Div., AF Ballistic Missile Div., "The Military Systems Planner"; and Ronald Smelt, director of research and development, Lockheed Missile Systems Div., "New Requirements in Missiles and Space Vehicles."

An interesting question-and-answer period followed. Sales and advertising executives in attendance were enthusiastic over the meeting, while symposium members welcomed the opportunity to present this type of information to a group, rather than to individuals, as is usually the case.

—I.H.

the first Western Regional Student Conference, chaired by Andrew F. Charwat of UCLA. Dr. Charwat explained at the beginning of the session that the conference was designed to aid students in the fields of rocketry and astronautics to complete their education by telling them a little about what they could expect once they entered these fields.

Toward this end, Dr. Charwat brought together a panel of students from UCLA, Cal Tech and USC and a group of engineers and scientists working in the field for a discussion of "The State of the Art in Rockets and Astronautics." Guest chairman George P. Sutton of Rocketdyne, ARS National President, provided a brief history of rocketry and astronautics and then introduced the guest speakers —P. Nichols of JPL, E. Zukowski of Cal Tech and E. Laitone of the U. of California at Berkeley.

Another innovation at the meeting was the ASTRONAUTICS-sponsored Advertising Symposium (see page 48). The Astronautical Exposition, held in the Wilshire, Assembly and Garden Rooms of the Statler, was also highly successful, getting heavy traffic throughout the meeting.

The Meeting Committee, under the leadership of Charles A. Knight of Space Technology Labs. Div. of Ramo-Wooldridge, General Chairman, and G. Daniel Brewer of STL, Southern California Section President, was fortunate in obtaining an excellent lineup of speakers for the well-attended luncheons and banquet which highlighted the meeting.

Banquet speaker Lee DuBridge, Cal Tech president, provided the 600 members and guests present at the event with some pointed comments on the nation's civilian rocket and space program while noting the difficulties involved in keeping the program aimed clearly at the target of gaining new scientific knowledge and of avoiding useless stunts which might discredit the entire endeavor. He pointed out that the public seems more concerned over how big a satellite we could put up or how soon we could get a monkey or a man into space than with the scientific results that such efforts would produce.

"The 'race into space' is not necessarily a race for more weight, but a race for more knowledge," he concluded. "And we will get more knowledge for our limited supply of dollars if we keep our heads—and if we keep control of the program in the hands of American scientists, and not let it be determined by what the propaganda hounds of the Kremlin decide."

In contrast to Dr. DuBridge, who confined his remarks to the civilian aspects of the space program, Rear Adm. John E. Clark, Deputy Director of ARPA, one of the luncheon speakers, discussed military requirements and problems in space, with special emphasis on the role man will play. His conclusion: Let the automatic instrumentation do what it can do better, and let man do that for which he is best qualified.

Another luncheon speaker, George F. Metcalf, general manager of GE's Missile and Ordnance Systems Dept., stressed still another aspect of our space flight program—the management aspect. Noting that the period in which any weapon can be decisive in a major conflict is shortening and that the complexity of such weapons is constantly increasing, he stressed the need for bearing these two points in mind in R&D programs so as to assure that future weapon systems will meet future needs and not be obsolescent by the time they go into production.

Norris Bradbury, director of the AEC's Los Alamos Scientific Lab, turned his attention to nuclear rockets in his luncheon address. Dr. Bradbury agreed that rockets using nuclear power would be far superior to chemically fueled rockets, but pointed out that many engineering problems still have to be solved before such rockets could fly. Among these problems are incorporating the energy from a nuclear reaction in a feasible fuel, designing materials capable of withstanding 2000–3000 F temperatures and carrying out long-term testing without contaminating equipment to a point where it could no longer be expeditiously used.

Dr. Bradbury also noted that the nuclear rocket test slated for the AEC's Jackass Flats, Nev., installation in October has been nicknamed "Kiwi" after a bird that does not fly, since only static ground tests would be made.

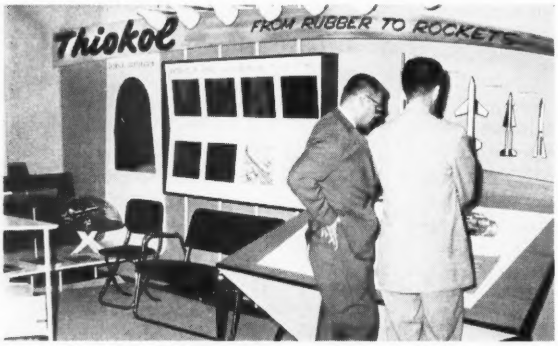
The meeting ended with a day of field trips to installations in the Los Angeles area, with over 175 ARS members and guests visiting Consolidated Western Steel Div. of U.S. Steel and JPL, Rocketdyne and Marquardt.

The outstanding success of the meeting was due in large measure to the efforts of Howard S. Seifert of Space Technology Labs, ARS National Program Chairman, the Technical Committee Chairmen, Messrs. Knight and Brewer, and the many Southern California Section members who contributed unstintingly of their time and effort both before and during the meeting.

—Irwin Hersey

Seen at the Exposition

Thompson showed a wide range of products.

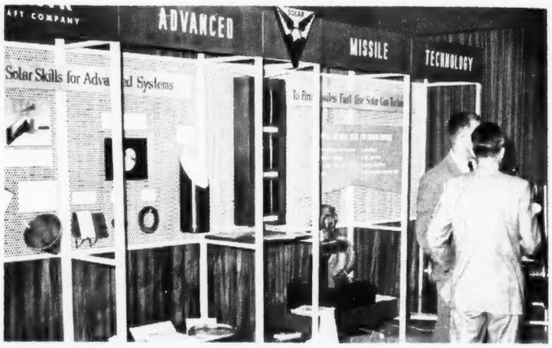


Two visitors have a look at latest Thiokol developments.

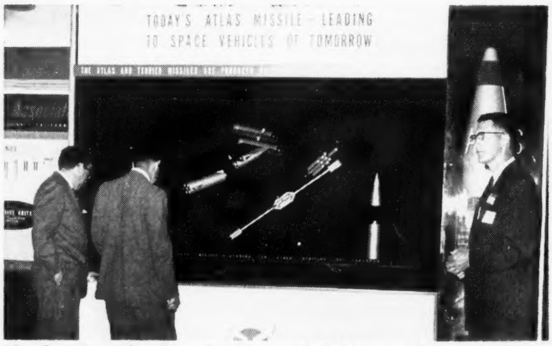
Possible Dyna-Soar model drew attention at Bell booth.

Thor ground handling equipment (at left) was featured by Ordnance Div. of Food Machinery & Chemical Corp.

Diversey's exhibit featured contour machining display.



The Solar Aircraft Co. exhibit.



Shadow box display of advanced design vehicles was highlight of Convair exhibit.

Aerojet engineer points out details of JATO unit display.

Program Set for ARS-IAS Regional Space Flight Meeting

The program has been set for the regional Space Exploration meeting co-sponsored by the San Diego Sections of ARS and IAS, to be held in San Diego Aug. 5–6. Morning and afternoon sessions will be held on both days.

The morning session on Tuesday, Aug. 5, will be devoted to economics and sociology, and will be chaired by J. R. Dempsey, Convair-Astronautics division manager. The session will center on a panel discussion of the roles of science, government, universities, the military and industry in space flight.

The afternoon session that day will deal with space technology, covering critical problems in propulsion, aerodynamics and controls. E. R. Van Driest, chief scientist, technical science, Missile Development Div. of North American, is session chairman.

A classified (Secret) session is scheduled for Wednesday morning, Aug. 6, on space research programs, covering the overall national program for space exploration, as well as current specific plans. Krafft A. Ehricke, assistant to the technical director, Convair-Astronautics, and chairman of the ARS Space Flight Committee, is session chairman.

The afternoon session the same day, chaired by J. E. Naugle, senior staff scientist, Convair Scientific Research Lab, will cover the physical properties of space and their effects on man's survival.

Detroit Meeting Looms As Outstanding Attraction

Fred Klemach, general chairman of the ARS Fall Meeeting scheduled for the Hotel Statler in Detroit, September 15–18, announces the schedule of sessions and other activities planned.

Highlights include a Secret session on Auxiliary Power Supplies, a Confidential session on Monopropellants, several sessions on production aspects of current missile programs and a forum on the "Impact of Space Flight on Industry." The classified sessions will be sponsored by the Detroit Ordnance Corps. The Chrysler Missile Division production areas, showing the Redstone and Jupiter missiles, will be the focus of a field trip scheduled for the final day of the meeting.

Tentative lineup is as follows:

Monday, September 15

Registration opens

Tuesday, September 16

9:30 a.m. Missile Production Problems (John Black, Hughes Aircraft, Chairman)
Long-Range Missile Components (Lewis Scheuer, Ford Instrument, Chairman)

Luncheon

2:30 p.m. Impact of Space Flight on Industry (Forum)
Controls for Supersonic Air-Breathing Engines (Brooks Morris, Marquardt Aircraft, Chairman)

7:00 p.m. Reception and Banquet

Wednesday, September 17

9:30 a.m. Monopropellants (Confidential) (Charles W. Tait, Wyandotte Chemical Co., Chairman)
Missile Manufacturing—Redstone and Jupiter (Charles W. Williams, Chrysler Corp., Chairman)

Luncheon

2:30 p.m. Auxiliary Power Supplies (Secret) (Arthur Ash, Sundstrand Turbo, Chairman)
Operational and Service Problems (Maj. Gen. John B. Medaris, Chairman)

Thursday, September 18

Field trip—Chrysler Corporation Missile Division, Redstone and Jupiter production operations

The complete program will be published in the September issue of ASTRONAUTICS.

Honors for ASTRO

G. D. Crain Jr. (right), publisher of *Industrial Marketing*, and ASTRONAUTICS Editor Irwin Hersey hold first-place plaque and certificate of merit awarded to ASTRONAUTICS in IM's 20th annual Editorial Achievement Competition for Business Publications. Awards were made at National Industrial Advertisers Assn. meeting in Chicago early in June.

Telemetering Conference Success—Lowy '59 Chairman

More than 500 engineers and scientists attended the 1958 National Telemetering Conference at the Lord Baltimore Hotel, Baltimore, June 2–4.

The meeting, sponsored by ARS, IAS, AIEE and ISA, was featured by 14 technical sessions on industrial telemetering, pickups, mobile airborne telemetering, medical telemetering, data processing, the IGY program, transistors and mobile ground measurements.

Some 40 companies had exhibits at the Conference, which was chaired by G. M. Thynell of the Applied Physics Laboratory, Johns Hopkins University. Elected to chairmanship of the 1959 Conference was Max Lowy of Data Control Systems, Stamford, Conn., representing ARS. Chairman of the 1959 NTC Executive Committee is James J. Harford, ARS Executive Secretary. The 1959 meeting is tentatively scheduled for May 25–27, in Denver.

Proceedings of the 1958 Conference are available from the ARS office at $4 per copy. —J.J.H.

Berkeley Hosts Heat Transfer Conference

Berkeley, Calif: About 200 specialists attended the 1958 Heat Transfer and Fluid Mechanics Institute conference held June 19–21 at the University of California, Berkeley.

Chairman of the proceedings, which were co-sponsored by ARS, ACS, ASME, AIChE, IAS, ASRE as well as Aerojet-General Corp., Lockheed Missile Systems Division and leading California universities, was Antoni K. Oppenheim, past-president of the ARS Northern California Section.

Well-attended sessions included more than 20 papers on fluid dynamics, dynamics of reactive fluids, heat transfer, physical chemistry, magnetohydrodynamics and hypersonics.

At a banquet on June 20, Theodore von Kármán addressed the group on "Modern Trends in Engineering Research and Education."

Nuclear Propulsion, MHD Technical Committees Formed

Formation of ARS Nuclear Propulsion and Magnetohydrodynamics Technical Committees was authorized at the June ARS board meeting. Stanley V. Gunn, manager, Project Rover, Rocketdyne, heads the Nuclear Propulsion Committee, and Milton U. Clauser, vice-president and director, Physical Research Lab, Ramo-Wooldridge, the Magnetohydrodynamics Committee.

Seek 25-Year ARS Members

ARS is in the process of compiling a list of all those who have been members of the Society for 25 years or longer. If you are in this category or know of anyone else who may be, please communicate with A. C. Slade, ARS Secretary, at national headquarters.

Four More Companies Become ARS Members

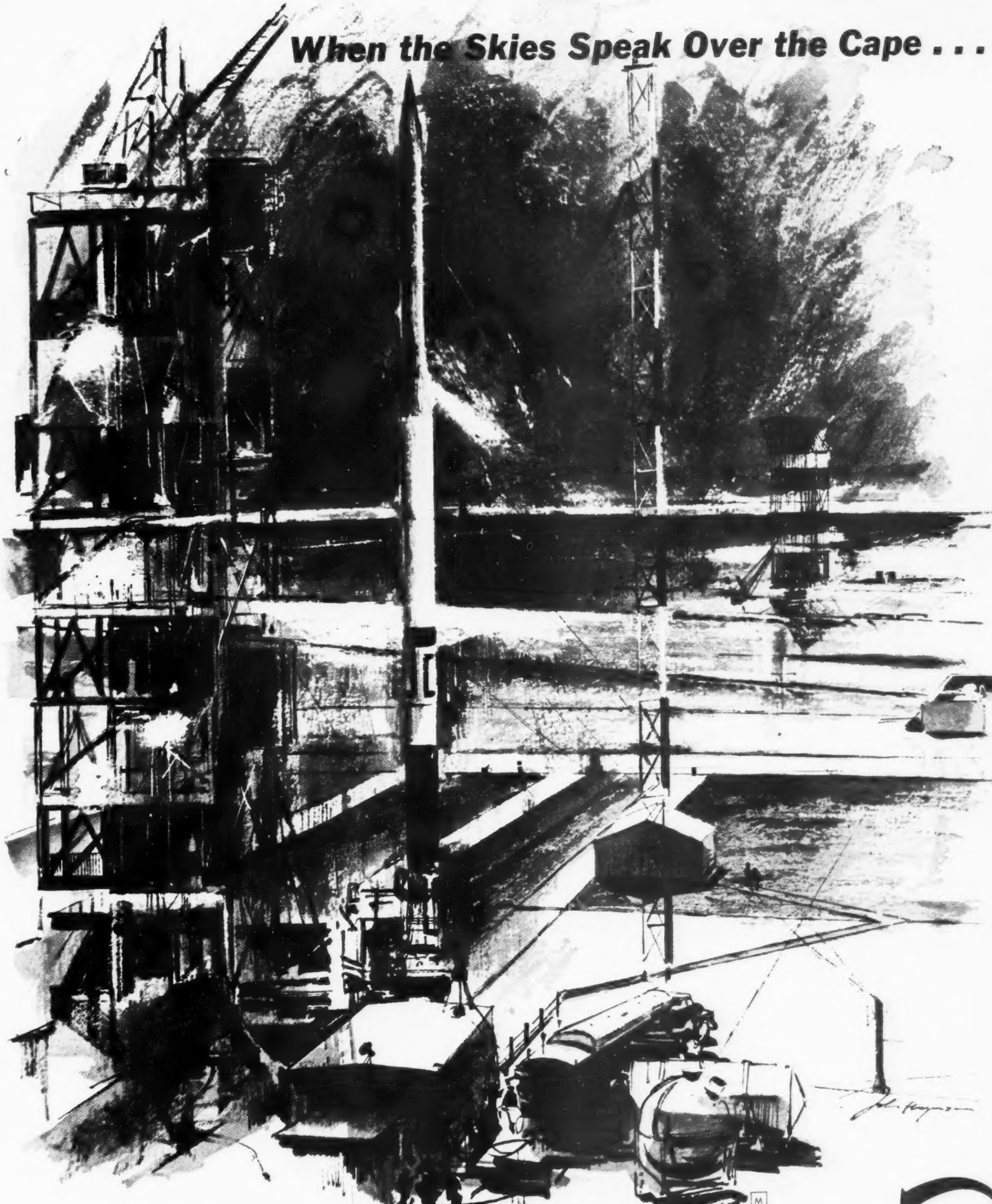
Four more companies have become corporate members of the American Rocket Society. The companies, their areas of activity and those named to represent them in Society activities are:

- **H. I. Thompson Fiber Glass Co.,** active in high-temperature reinforced plastics (to 10,000 F for short duration), 2000 F insulation materials, welded metal honeycomb and high temperature metal foil blankets. Representing the company in ARS are: Leon Parker, vice-president, research and development; Raymond Cutler, chief engineer; Robert Nordberg, manager, New Products Div.; C. S. Brown, assistant executive, field engineer; and W. E. Benke, vice-president, sales engineering.

- **The Decker Corporation,** active in research and development of instrumentation for control and measuring systems. Named to represent Decker in ARS are: Martin M. Decker, president; Thomas W. Spirito, vice-president; Col. Neil B. Harding (AF-Ret.), assistant to the president; Theodore Kaslow, vice-president, engineering; and Raymond H. Lazinski, director, research and development.

- **Astrodyne, Inc.,** active in research and development, and manufacture of complete solid-propellant propulsion systems, extruded and cast propellants, rocket engines, missile controls and hardware, boosters, gas generator charges and auxiliary power. Representing the company in ARS are: J. A. Reid, executive vice-president; R. J. Martinelli, manager, Manufacturing Dept.; R. L. Storer, manager, quality control; K. P. Johnson, manager, contracts and proposals; and R. K. Moore, director, public relations.

- **Brown Engineering Co.,** active in engineering services in research and development; electromechanical instruments, electronic research and development, machine shop services, fabrication and graphic arts. Named to represent the company in ARS are: M. K. Cummings, president; J. E. Hatch Jr., first vice-president; G. F.


When the Skies Speak Over the Cape . . .

On the calendar

1958

Aug. 5–6	**Space Exploration Meeting sponsored by ARS, IAS, San Diego Sections.**
Aug. 7–15	Heat Transfer Course given by Heat Transfer Lab. of the Mechanical Engineering Dept., U. of Minnesota.
Aug. 13–21	10th Assembly of the International Astronomical Union at Moscow.
Aug. 18–23	Systems Engineering and Missile Operations Seminar, Pennsylvania State U., University Park, Pa.
Aug. 25–30	**Ninth Annual Congress of International Astronautical Federation, Amsterdam, The Netherlands.**
Sept. 1–6	1958 Farnborough Flying Display and Exhibition, Farnborough, England.
Sept. 3–5	1958 Cryogenic Engineering Conference, MIT, Cambridge, Mass.
Sept. 8–13	First International Congress of Aeronautical Sciences, sponsored by IAS, Madrid, Spain.
Sept. 15–18	**ARS Meeting, Hotel Statler, Detroit, Mich.**
Sept. 22–24	IRE National Symposium on Telemetering, the American Hotel, Bal Harbour, Miami Beach, Fla.
Oct. 13–15	National Electronics Conference, sponsored by IRE, AIEE, EIA, Hotel Sherman, Chicago.
Oct. 14–16	**ARS New Mexico-West Texas Section and American Meteorological Society High Atmosphere Conference, El Paso, Tex.**
Nov. 10–12	AF School of Aviation Medicine-Southwest Research Institute Space Symposium, Hilton Hotel, San Antonio, Tex.
Nov. 17–21	**ARS 13th Annual Meeting, Hotel Statler, New York, N.Y.**
1959	
April 5–10	Fifth Nuclear Congress of Engineers Joint Council, Cleveland Auditorium, Ohio.

Epps, chief engineer; G. H. Gross, chief, field engineer; and W. L. Vernon, treasurer.

SECTIONS

Alabama: Herbert L. Karsch, head of field-test operations and director of Project Farside for Aeronutronic Systems, Inc., addressed the section May 29 at the Huntsville Utilities Building. He discussed the objectives of Project Farside, the balloon and rocket hardware used, field operations and flight dynamics of the vehicle, and data gathering and telemetering. The Farside rocket, which may have gone as high as 4000 miles above the earth's surface, employed modified solid-propellent Recruit rockets in the first two stages. The Recruit was originally developed by Thiokol's Redstone Div. at Huntsville for Lockheed's X-17 reentry test vehicle.

—R. G. Higginbotham

Cleveland-Akron: Two meetings were held in May. At the first, to which more than 40 students from Fenn and other local colleges were invited as guests, Gerald Morrell, chief of the NACA Lewis Flight Propulsion Lab's rocket chemistry branch, spoke on "Combustion of Solid-Rocket Propellants." At the second meeting, members discussed the possible formation of a student chapter in the area.

Dayton: Standing room only attendance of over 225 members and guests at the new Dayton Section's charter meeting, held as a dinner at the Sky Terrace Room of the Miami Hotel, saw Col. John P. Stapp, ARS National Vice-President, present the charter to the section's first president, William J. Cushing. Col. Stapp showed a color documentary film of his now famous sled rides after the presentation.

In addition to Cushing, these officers were elected: Capt. Roderick W. Clarke, vice-president; Mrs. Maxine M. McKee, secretary; and Alfred C. Loedding, treasurer.

The section held its second meeting June 12 at the Dayton Engineers Club. Some 200 members and guests heard Walter Dornberger, former military chief of the German V-1 and V-2 missile programs, speak on "Planning for the Space Age." Dr. Dornberger expressed the opinion that the first nation which solves the problem of returning a space vehicle with crew to a predetermined landing area has the best chance of controlling space, and that this problem must be solved before trips to the Moon or Mars are undertaken.

—William J. Cushing

For a Job Well Done

Col. John P. Stapp, ARS Vice-President, congratulates Dayton Section's first president, William J. Cushing of Burroughs, on role he played in formation of new ARS group. Col. Stapp presented the charter to the section at a meeting April 22.

Florida: W. E. Zisch, vice-president and general manager of Aerojet, addressed the section June 20 on "Research—Key to Rocketry's Future." Noting the vast scientific and technological strides made since the advent of the airplane, he came boldly to this question: "Can we look forward in the next 30 or 40 years to speeds of 200,000 mph or more?" He admitted it would take a great investment in time and money, but felt that this investment would bring profit beyond the imagination of any script writer.

Maryland: The section held its annual award dinner June 16, with the Westinghouse Air Arm Div. as cordial host. Some 170 members and guests gathered at the Friendship International Airport Galaxy Room for a convivial cocktail and then traveled to nearby Air Arm for dinner in the plant's spacious cafeteria.

Before the meeting, members and guests had the pleasure of a brief tour through the division's digital and analog computing facility, with Andrew McCourt, head of the Analytical Section, showing the way and answering questions.

S. W. Herwald, manager of the division, opened the meeting with a welcome, and expressed Westinghouse's pleasure in advancing the professional interests of its staff and encouraging organizations such as ARS. He turned the meeting over to section president Samuel Fradin of Miller Laboratories, who introduced the officers elected for the coming year: Elliot Felt Jr. (Martin Co.), president; Harold J. Hasenfus (BRL), vice-president; Ralph P. Gray (Air Arm), secretary; and Howard C. Filbert (Miller Lab.), treasurer.

Ivan E. Tuhy, staff engineer for Martin and chairman of the ARS Solid Rocket Committee, then presented a scroll and shield to Peter A. Castruccio for being the section member who has

contributed the most to rocketry in the past year. Dr. Castruccio has been working in both radar and propulsion.

Dr. McCourt introduced the guest speaker, George C. Sziklai, vice-president in charge of engineering for Westinghouse Electric Corp., who discussed communication and navigation in space. Using a fine set of color slides for illustration, Dr. Sziklai considered some problems of power and reliability for a space ship, relating them, for example, to midcourse guidance in a trip to the moon. He mentioned the importance of current work on thermionic oxides for power conversion of radiant energy, and the possible use of a highly resolved light beam from earth for attitude control of a moon vehicle. His wit in drawing anologies helped make a variety of technical points understandable to the uninitiated, and both members and guests enjoyed his discussion.

This brought to a close a thoroughly enjoyable meeting, and one giving considerable evidence of the section's enthusiasm and activities.

—John Neubauer

National Capital: This section and the National Rocket Club sponsored a Missile Industry Conference in Washington early in June. At the Robert H. Goddard Memorial Dinner which highlighted the event, L. Eugene Root, vice-president and general manager of Lockheed's Missile Systems Div., accepted the Borg-Warner Award presented to the "organization that contributed most in the past year to the development of the art of missiles and astronautics," for his company. The basis of the award was Lockheed's work in pioneering the application of solid-propellant power to the U.S. ballistic missile program through its X-17 and Polaris projects.

Wernher Von Braun received an award for individual achievement at the dinner.

Featured speaker of the evening was Lockheed's board chairman, Robert E. Gross.

North Texas: The dinner meeting held June 5 at the Commissioned Officers Mess of the Naval Air Station in Dallas was attended by 130 members and guests, who heard Robert C. Truax, Capt., USN, describe some of the activities and problems of the Advanced Research Projects Agency.

Northeastern New York: The section plans regularly scheduled meetings this fall, as it appears that growing interest in rocketry will increase membership. A membership poll produced these goals for the coming season: To help establish and maintain a personal relationship with others in the field; to assist in the technical education of the membership; and to foster general community interest in rocketry. Meetings in the fall will feature semitechnical lectures and discussions of topics of current interest.

—F. W. Crimp Jr.

Pacific Northwest: The University of Washington's student chapter completed its first year in ARS with a student paper contest sponsored by the Pacific Northwest Section and the election of officers for the coming school year. New officers and the winning paper were presented to the section at a joint meeting at the Rainier Golf and Country Club in Seattle.

G. Truxton Ringe, section president, awarded $25 to Mike Maes for his prize-winning paper, "The University of Washington's Rocket Test Stand." R. E. Street, professor of aeronautical engineering at the University of Washington, and faculty adviser to the student chapter, introduced the new student officers: Dennis Leigh, president; Dave Evans, vice-president; Nick Kopta, treasurer; Donald Ciffone, corresponding secretary; and Gary Laughlin, recording secretary.

—Donald L. Ciffone

Philadelphia: Edwin M. Partridge Jr., senior engineer in the systems group of the Vitro Labs' Development Engineering Dept., spoke at the April meeting on "Inertial Guidance of Cruise and Ballistic Missiles." His discussion of this timely subject was well received. At the May meeting, held at the Fels Planetarium of the Franklin Institute, Erik Bergaust, editor of *Missiles and Rockets*, spoke on "The Soviet-American Race to the Moon."

—G. Barth-Wehrenalp

Sacramento: The section held three meetings during April and May. In the year's first nondinner meeting on April 14, Jack C. Van Paddenburg, manager of Aerojet's Data Processing Div. and three other members—Leo Day, Don Jackson and George Sain—addressed over 40 members and guests on the topic, "Large-Scale Automatic Computers and Their Applications." Van Paddenburg describing the basic types of computers and the principles of their operation, and the others their special fields—Day, data reduction; Jackson, the advantages of digital computers; and Sain, areas in which analog computers shine.

A second meeting was held at the El Morado Hotel in Sacramento May 1. Bernard S. Benson, president of

Benson & Lehner Corp., addressed 80 members and guests on "Do-It-Yourself Thinking in an Age of Togetherness." The design philosophy of the company, which produces data processing equipment and other devices for the missile industry, served as one illustration of how logical problem solving by individuals can compare with the fad of group discussion "brain-storming." Benson presented with inspiring verve an argument for individual thinking in today's space age.

The spring dinner meeting of the section, held May 27 at the Sacramento Inn, and attended by some 50 members and guests, featured a talk by Peter G. Weiser, an assistant for special studies at Ramo-Wooldridge, on "Operations Research Can Be Practical." He described operations research as an invaluable aid to all levels of management in the resolution of complex problems, and described how operations research teams under his direction had predicted the outcome of several problems in large liquid engine development programs.

—George S. James

San Diego: About 85 members and guests heard H. W. Ritchey, technical director of Thiokol's Rocket Div., discuss recent advances in large solid-propellant rockets at a meeting held May 22 at Convair-Astronautics' new executive dining room. Dr. Ritchey stressed the great future of solids, compared with liquid propellants, which he described as a flying "processing plant."

Giving credit to JPL for early impetus, he gave a brief history of solid-propellant development. In discussing some technical parameters, he noted humorously that in 1949 it would have been possible to put an empty beer can on the moon with a five-stage, 500-lb gross weight vehicle.

Finally, Dr. Ritchey discussed a theoretical solid booster of nearly 2-million-lb thrust and some 425-ft long, based on a scaled up Recruit rocket. He doubts the practicality of assembling space ships while in orbit using liquid-propelled ferry-freight rockets, but admitted that the higher mass ratios and low accelerations of liquid rockets are favorable for manned and inertial guided flight.

—Daniel A. Heald

Southern California: Held at the Aeronautical Sciences Building in Los Angeles on May 22, the regular monthly meeting featured two speakers—Robert L. Cornog of Ramo-Wooldridge's Space Technology Laboratories and Martin Rosenbloom of Rocketdyne.

Dr. Cornog, speaking on "Propulsion of Interplanetary Vehicles," explained the limitations of rockets with chemical propellants in terms of heat energy available; temperature limitations of nuclear reactor powered engines; and possibilities for electrical propulsion devices. He showed that, for electrical systems, power requirements increase as the square of exhaust velocity. Despite this, he believes that payloads amounting to 60 to 80 per cent of total space vehicle weight appear possible with electrical systems, as compared with payloads of only 1 or 2 per cent with chemical rockets.

Rosenbloom discussed nuclear propulsion, comparing nuclear and chemical energy potential and describing some of the problems of engineering a small reactor with large content of pure Uranium 235, and not enriched natural uranium, which can be used in ground reactors. He mentioned as suitable neutron reflectors beryllium and its oxide, which are unfortunately expensive, toxic, brittle and hard to fabricate; graphite; deuterium oxide and water. He also pointed out three possible methods of reactor control—axial neutron-absorbing rods of such metals as cadmium and boron; working fluid with a neutron absorber; and liquid reflectors, in which thickness varies power level.

For a typical airborne reactor using a working fluid of hydrogen at 4000 F and 800 psi, he gave a length of 6 ft and a frontal area of 6.5 sq ft. This unit would produce a thrust of 100,000 lb. In conclusion, he cited the need for more advanced performance than this for space flight. Plans for these seem tentative, he noted.

The meeting concluded with a showing of an AF color movie of Atlas and Thor firings, made available through the courtesy of Space Technology Laboratories.

—Eric Burgess

TECHNICAL COMMITTEES

Space Flight: Walter R. Dornberger of Bell, Grayson Merrill of Fairchild Guided Missile Div. and Howard Seifert of Space Technology Labs Div. of Ramo-Wooldridge have been appointed to the Space Flight Committee, succeeding George Clement of Rand Corp., Richard Porter of GE and Milton Rosen of NRL.

CORPORATE MEMBERS

Ramo-Wooldridge has announced plans for the separate incorporation of its Space Technology Laboratories, which has been functioning as an autonomous division.

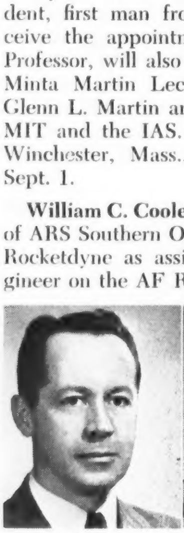
Consolidated Electrodynamics has completed construction of two 57,500-sq ft buildings in Monrovia, Calif., to house its Systems and Transducer Divs., previously located in Pasadena.

People in the news

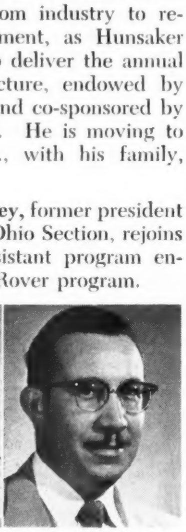
APPOINTMENTS

George P. Sutton, manager of advance design, Rocketdyne, has been appointed Jerome Clarke Hunsaker Professor of Aeronautical Engineering at MIT. Normal tenure for the post, an endowed visiting professorship, is one year. The ARS National President, first man from industry to receive the appointment, as Hunsaker Professor, will also deliver the annual Minta Martin Lecture, endowed by Glenn L. Martin and co-sponsored by MIT and the IAS. He is moving to Winchester, Mass., with his family, Sept. 1.

William C. Cooley, former president of ARS Southern Ohio Section, rejoins Rocketdyne as assistant program engineer on the AF Rover program.



Shane



Webster

Presson S. Shane joins Atlantic Research Corp. as director of the newly formed Solid Propellant Div. **Robert O. Webster** has been appointed director of the new Mechanical Engineering Div. Shane was formerly with McGean Chemical Co. and Webster, formerly head of AR's Missile Engineering Group.

Roger E. Robertson, former assistant project manager, Hughes Aircraft, becomes chief engineer at B&H Instrument Co.

Yusuf A. Yoler, former investigations manager, Aerodynamics Lab., Missile and Ordnance Systems Dept. of GE, has joined Boeing Scientific Research Labs., where he will direct research in the field of gas dynamics.

Maj. Gen. Clayton C. Jerome (USMC), retiring as Commanding General, Aircraft, Fleet Marine Force, Pacific, will head industry development for Budd Co.

Burroughs Corp. has named **U. C. S. Dilks,** former manager, Research Div., associate director of commercial products; **Edward Lohse,** former manager, Ballistic Missile Div., associate director of defense products; and **J. H. Howard,** former manager, Advanced Development Div., manager, R&D Div.

Lewis A. Barry, former supervisor, Callery Chemical Co.'s Process Engineering and Development Dept., has been named operations manager, R&D Div.

George H. Hoeck, former secretary, Chicago Aerial Industries, has been elected vice-president and director of manufacturing and **Herbert W. Heffernan,** former assistant to the vice-president in charge of engineering and customer relations, has been named manufacturing manager under Hoeck.

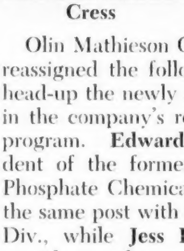
Phillip W. Lett has been promoted from assistant chief engineer to chief engineer, Chrysler Defense Engineering, while **Walter C. Beyer** becomes assistant chief engineer.

Ira G. Ross, former executive vice-president and director, Cornell Aeronautical Lab., has been elected president.

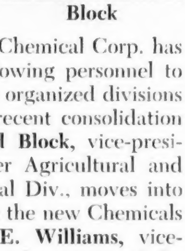
James Peterson joins Cyril Bath Co. as chief engineer. He formerly was supervisor, special machine design and manufacturing of test equipment, Chance Vought Aircraft.

Food Machinery and Chemical Corp.'s Chemical Div., has upped **Hans O. Kauffmann,** former technical director, Becco Chemical Div., and **Oscar H. Johnson,** former director of research, Niagara Chemical Div., to directors of Research and Development, Inorganic and Organic Chemicals Depts., respectively.

Herbert C. Cress, former vice-president of operations for the Sperry Rand Corp. Sperry Farragut Div., has been appointed to the newly created post of vice-president and works manager, Ford Instrument Co.

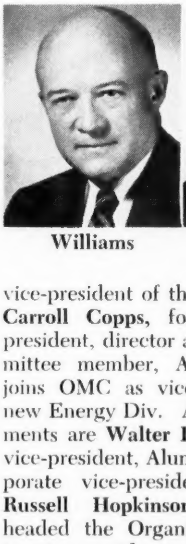


Cress



Block

Olin Mathieson Chemical Corp. has reassigned the following personnel to head-up the newly organized divisions in the company's recent consolidation program. **Edward Block,** vice-president of the former Agricultural and Phosphate Chemical Div., moves into the same post with the new Chemicals Div., while **Jess E. Williams,** vice-president and general manager of the former Western Brass Div., becomes



Williams

Copps

vice-president of the new Metals Div. **Carroll Copps,** former senior vice-president, director and executive committee member, Atlas Powder Co., joins OMC as vice-president of the new Energy Div. Additional appointments are **Walter F. O'Connell,** from vice-president, Aluminum Div., to corporate vice-president, finance, and **Russell Hopkinson,** who formerly headed the Organic Chemical Div., to vice-president, commercial development.

Grayson Merrill, general manager, Fairchild Guided Missiles Div., has been named acting technical director of a newly created Technical Dept., overseeing separate research and engineering departments. **Richard H. Braun,** director, physical research lab., will head the Research Dept., and **Elmore P. Pillsbury,** chief engineer, the Engineering Dept. Under Dr. Braun are **Roy Spacie** who will be assistant director, research; **Walter F. Grasse,** former senior research physicist, as chief, Physics Div.; and **S. L. Quick,** head, Advanced Design Div. **L. D. Van Valkenburgh,** former chief, Guidance and Control Development Div., has been appointed technical assistant to the Technical Dept. director.

Norman Meyers has been appointed research specialist, Lockheed Missiles Div.

Col. William O. Davis, assistant director of laboratories, Wright Air Development Center, and previously deputy commander for operations of AFOSR, has resigned from the Air Force. He is joining Turbo Dynamics Corp. as vice-president for research.

Gerald Rosenberg, director and vice-president, Consolidated Diesel Electric Corp., has been elected to the new post of group vice-president, responsible for the company's Aircraft, Power and Test Equipment Divs.

William H. Duerig has been appointed vice-president, research and engineering, Midwestern Instruments, Inc.

Gerald M. Henriksen, former director, research and engineering, AMF Turbo Div., has been elected director and vice-president, Acoustica Associates, Inc., and **Frank P. DeLuca Jr.** vice-president, has been made responsible for operation of West Coast facilities.

Lockheed Aircraft announces six top executive appointments at its Georgia Div. **James P. Lydon,** former director of administration, has been named assistant manufacturing manager; **Fred N. Dickerman,** former chief preliminary design engineer, assistant chief engineer; **F. A. Cleveland,** former preliminary design engineer, chief advanced design engineer; and **E. B. Gibson** preliminary design division engineer. At the company's Missile Systems Div., **Clare W. Harris,** formerly in charge of the Reliability Div., Polaris project, has been named to head the newly formed quality assurance branch. **Richard P. DeGrey,** former project engineer at Van Nuys, has been appointed program planning division manager for the project systems branch.

Edmund Basich, former production manager and vice-presidential assistant, Statham Instruments, Inc., has been elected vice-president, manufacturing.

B. E. Heacock, former manager, advanced design, Stavid Engineering, Inc., has been named manager of the new Preliminary Design Dept.

Walter H. Owen and **Earl L. Casey** have been appointed general manufacturing superintendent and manager of division services, respectively, of Texas Instruments Inc. Apparatus Div. Owen was formerly manager of TI's manufacturing precision optics facility, and Casey was formerly general superintendent of manufacturing, Apparatus Div. **J. S. Dufford,** formerly assistant vice-president and manager of manufacturing, has been named to the newly created post of assistant vice-president and head of quality assurance and industrial engineering.

Thracy Petrides, former manager, R&D Labs., Bulova Advanced Systems Dept., will head U. S. Industries' newly formed Military Systems Planning Group.

Kuang Lu Cheng and **Adolph Edward Palty** have been named associate director of research and supervisor, alloy development evaluation, respectively, of Kelsey-Hayes Co.'s Utica Metals Div.

Norman Hiestand, former manager, Power Tube Applications Dept., Varian Associate's Tube Div., has been made manager, product development, Instrument Div.

William Q. Nicholson, has been appointed associate technical director and manager of engineering plans and programs, BJ Electronics, Borg-Warner Corp.

Ali B. Cambel, professor of mechanical engineering, Northwestern University and associate editor of Jet Propulsion, succeeds Professor Burgess Jennings as chairman of the department.

Col. Paul A. Campbell, formerly with the AF Office of Scientific Research, has been reassigned to the School of Aviation Medicine, heading up an expanding Space Medicine Div.

Karel J. Bossart, on leave as technical director, Convair-Astronautics, is acting assistant for missile engineering to R. C. Sebold, vice-president, engineering at Convair. **John C. Clark,** former staff assistant, Astronautics Div. manager, will be Sebold's technical and scientific assistant.

A five-man research board has been established at Garrett Corp. under the chairmanship of **W. T. von der Nuell,** former director, D. V. L. Institute for Turbomachinery, Berlin. Other members are **John Mason,** chief of preliminary design; **A. P. Kelley,** chief of preliminary design at AiResearch of

Arizona; **Hans Egli,** in charge of turbocharger development; and **J. E. Chapman,** assistant chief engineer, electrical and electronics equipment, air data and missile guidance equipment.

W. S. Bobier, former engineering section head, Vickers component development section, becomes chief engineer, Detroit activity, Aero Hydraulics Div.

Joseph M. Denney has joined Hughes Aircraft's Nuclear Electronics Dept.

Eugene J. Vigneron, has been named manager, Needham (Mass.) operations, of Sylvania's Electronic Systems Div. and **John B. Donner** becomes project manager, electronic defense subsystems for SAC's B-52.

Two MIT senior professors in aeronautical engineering and physics, respectively, have been appointed consultants to National Research Corp. They are **Raymond L. Bisplinghoff,** a member of NACA's Committee on Aircraft, Missile and Space Craft Construction and **Wayne B. Nottingham,** former vice-president of research, Electronics Corp. of America. In addition, **John M. Lee** has been promoted to coordinate all space activities between the various departments and consultants in the company's space program.


Swift **Lund**

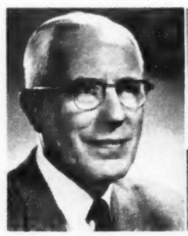
L. R. Swift, former director of production, Minneapolis-Honeywell's Aeronautical Div., has been promoted to special assistant to W. T. Noll, manager of production and procurement. **Ed Lund,** former plant manager, succeeds Swift.

Peter J. Schenk, former manager of marketing, Technical Military Planning Operations, GE, and Air Force Assn. president, has been named assistant to the president for government marketing, Raytheon Mfg. Co.

A. W. Orlacchio has been appointed chief engineer of the Gulton Industries, Glennite Instrumentation Div.

Philip S. Fogg, chairman of Consolidated Electrodynamics Corp., has been elected president; **Hugh F. Colvin,** former president, has been named senior vice-president, Pasadena Divs.; **Kennett W. Patrick,** former director, Transducer Div., vice-president, Monrovia Divs.; and **Frank M. Jenner,** former general manager, Rochester Div., to vice-president of that division.


Patrick **Jenner**




Heyn **Bell**

Henry M. Heyn has been elected president of Surface Combustion Corp., and also president of the Toledo (Ohio) Industrial Div. **Robin A. Bell,** former director and vice-president of SCC, and general manager of Columbus operations, has been appointed executive vice-president of the corporation, and president of the two Janitrol divisions in Columbus. **James P. Farrell** will serve as vice-chairman and **Albert J. Buckenmyer,** as secretary and treasurer.

HONORS

Eugene Root, Lockheed vice-president and Missile Systems Div. general manager, has received an honorary D.Sc. degree from his alma mater, the College of the Pacific.

Carl W. Keuffel, president of Keuffel and Esser Co., has received an honorary Eng.D. degree by Stevens Institute of Technology for his "many contributions to the field of measurements." **J. Paul Walsh,** deputy director of the Navy's Vanguard project, also received an honorary Eng.D. from the Institute.

Chauncey Starr, vice-president, North American Aviation, and general manager of its Atomics International Div., has been elected president of the American Nuclear Society.

RCA has been awarded a Navy Certificate of Merit for development of the Talos defense unit, the first completely automatic missile firing and guidance system.

Army Proposes Sending Man Into Space Via Redstone

Herbert F. York, ARPA chief scientist, recently told a House subcommittee that the Army has submitted a plan to the agency to send a man aloft via a Redstone missile, keep him there for six minutes and return him safely to earth. While details of the project are still classified, the proposal reportedly calls for providing room for the volunteer space man in the Redstone's warhead section, which would re-enter the earth's atmosphere and land safely by means of a multiple parachute system.

Polaris Progress Reported

The nose cone for Polaris has reached an advanced stage of development, according to Rear Adm. W. F. Raborn, director of the Special Projects Office of the Navy Bureau of Ordnance. Playing a key role in the development of the nose cone has been a version of Lockheed's solid-propellant X-17 ballistic rocket, which has been sent hundreds of miles into space numerous times for this purpose.

Recent firings in the Polaris program have involved new solid rockets devised by Lockheed Missile Systems Division specifically for flight-testing other Polaris components and systems.

Space Technology Film Series Produced by U. of California

A 17-program series of 16-mm films on Space Technology, lasting about 45 hours, will be released shortly by the University of California, Los Angeles. Some of the outstanding lecturers in the film include: Wernher von Braun, ABMA; Joseph Kaplan, Chairman, IGY National Committee; Hubertus Strughold, School of Aviation Medicine; Martin Summerfield, professor of aeronautics, Princeton University and Editor, JET PROPULSION; and William H. Pickering, director, JPL, California Institute of Technology.

The complete series will rent for $2300, along with two sets of lecture notes.

NACA has already purchased the series and is showing the films, which are actually kinescopes of the University's Space Technology Course, given early this year, in Washington.

New Lox-Nitrogen Plant

Linde Co., Div. of Union Carbide Corp., has announced that it will build a 300 ton-a-day lox and nitrogen producing plant at Pittsburg, Calif.

Metal Forming

(CONTINUED FROM PAGE 24)

by extrusion. The closed die forging method produces excellent results, but the high specific pressures required to forge thin panels impose severe limitations on the area that can be forged, even on the largest available presses.

Progressive forging of long strips has been attempted. Recent joint experiments by the Wyman-Gordon Co. and Engineering Supervision indicate the feasibility of this method with no limitations in length and with the width limited by the width of press beds only.

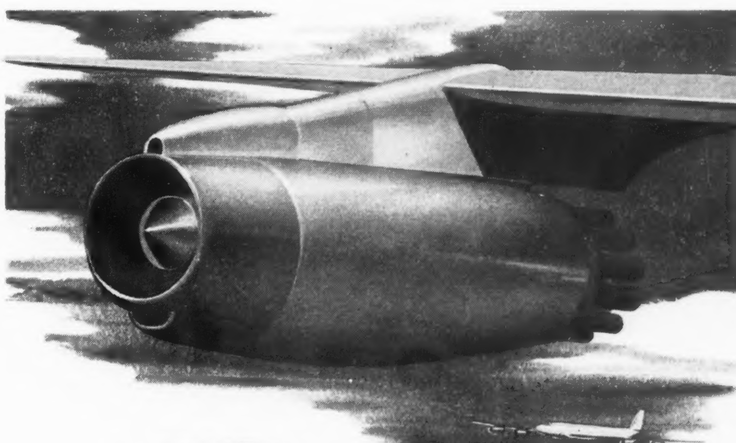
Hot spinning and hot dishing have been successfully applied to production of large elements of missile structures. It must be realized, however, that these methods require a large amount of subsequent machining, and therefore cannot compete with closed die forging or cold deep drawing whenever these latter methods are feasible.

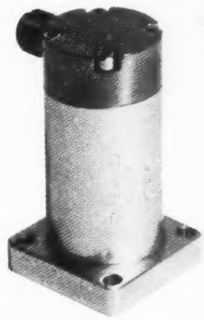
It is important to emphasize that plastic forming to final dimensions is extremely attractive from the viewpoint of manufacturing cost and metal economy. It is therefore understandable that many attempts have been made to expand the area of plastic forming.

A striking example is the generation of high pressures by means of explosives. Olin-Mathieson is successfully applying this method to forming and deep-drawing of sheets, as well as tubular shapes. Experiments are on the way to apply this method to closed die forging and extrusion. These experiments are in too early a stage to indicate even approximately what the limitations of this process will be with reference to sizes of products.

The principle of minimum weight design has been applied particularly successfully to honeycomb structures and curtain walls. Small panels of this type have been produced successfully for many years. Very large, very light panels are needed now. Developments and experiments underway indicate the feasibility of panels up to 200 ft sq, and possibly larger. Further research in this field will be necessary before panels of this size can be released for regular production.

In addition to new structural concepts, the age of missiles has brought new manufacturing problems in the field of hardware for powerplants. The most important is the problem of manufacturing of nozzles like the one shown on page 24. Multiple ram presses provide effective production





means for relatively small nozzles. Big ones, however, cannot be produced on available presses, and must of necessity be either fabricated by welding or hogged out of solid billets. Neither of these two methods represents a satisfactory solution; welding seams are not always acceptable, and machining of solid blocks results in an unreasonable amount of chips of expensive materials that sometimes cannot be used even for remelting.

Certain sizes of nozzles can be produced by rough forging and subsequent high-pressure spinning. No equipment is available to produce large sizes by this method.

Hot forming should, however, provide the most satisfactory method for manufacturing large nozzles. Equipment which would allow production even of the largest has been developed and could be built.

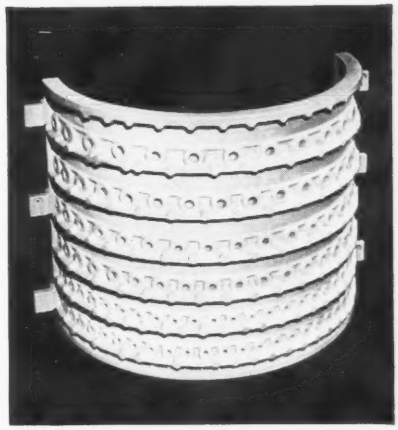
A new and unexplored manufacturing tool is the application of extremely high pressures for the improvement of physical properties of materials (not only metals) and for the development and production of new metallurgical compositions. The successful application of high pressure (100,000 atm) to the transformation of graphite into diamond is very encouraging. Our company has designed high-pressure cavities large enough to subject metals and other material to pressures of 100,000–150,000 atm. It is expected that these high pressures will reveal new structural phases in several important metals, cermets and other materials.

A remark on the need for better interchange of information might fittingly conclude this brief review. Lack of communication in the field of research and development in general, and on manufacturing methods in particular, was realized long ago. Unfortunately no systematic attempt has been made to alleviate the prevailing conditions. An industrial advisory committee on manufacturing methods and industrial equipment, consisting of representatives of government, research organizations, producers, fabricators and machine builders, given proper authority to enforce communication in this field, would greatly contribute to urgently needed progress in our missile and space programs.

Satellite Report Available

Number 10, Vol. 2 of the Smithsonian Contributions to Astrophysics, entitled "Orbital Data and Preliminary Analyses of Satellites 1957 α and 1957 β," are available for $1 from the Superintendent of Documents, Government Printing Office, Washington 25, D.C.

Zirconium, thorium, cerium . . . strange names for little known, little used elements. But add them to magnesium, and a new family of metals appears. Preserving the high strength-weight ratio of the featherweight metal, they add high-temperature properties that have proved a necessity in high performance aircraft and missiles. A specialist in light metals casting, Rolle knows these alloys as you know the back of your own hand.



how to save weight at high temperatures

an introduction to the magnesium-rare earth-thorium alloys

One-fourth the weight of steel . . . two-thirds the weight of aluminum . . . magnesium has carved a featherweight niche for itself in modern materials engineering.

But the reputation won by the magnesium-aluminum zinc alloys was won at room temperatures. Where high temperatures obtain, the "structural" alloys are no longer structural, and the lesser known "premium" group comes into its own.

These alloys, providing excellent high temperature properties and creep resistance to 660F, are also characterized by

- uniform strength of varying cross-section
- high fatigue strength
- low notch sensitivity
- freedom from microporosity
- good stress rupture characteristics
- good founding qualities

Naturally, properties vary within the group, but a rough comparison of individual advantages can be drawn.

a profile of the "premium alloys"

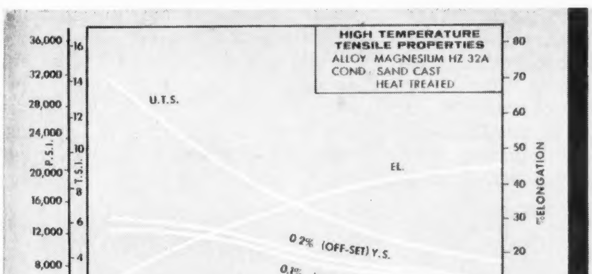
ZK51A and ZE41XA are superior, fine grained alloys with high yield strength and ductility, excellent fatigue properties, low notch sensitivity, and they are pressure tight without impregnation. Alloy ZH62XA offers these same general properties but is stronger than ZK51A. The room temperature strength of ZH62XA is combined in a relatively new alloy, ZH42, with creep resistance to 480F.

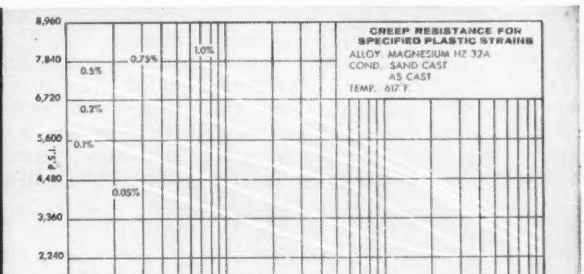
Complete freedom from microporosity, excellent founding properties, and low heat treating temperatures, characterize EZ33A, a magnesium-zirconium-cerium alloy. Like ZH42, EZ33A resists creep to 480F, and possesses good tensile properties at both normal and elevated temperatures.

HZ32A, perhaps the most important alloy of the series, contains thorium rather than cerium. Equal to EZ33A in strength, founding properties, and heat treating characteristics, it resists creep to 660F.

ideal for engine castings

Though each of these "premium" alloys offers specific advantages, the benefits of HZ32A have undoubtedly been most impressive. Its unique heat resistance properties permit weight savings in stressed turbine engine parts with magnesium castings for the first time. A typical example is the part illustrated above . . . a jet engine compressor housing . . . sand cast by Rolle in HZ32A. Success of this alloy in such applications can be inferred from the two graphs—High Temperature Tensile Properties and Creep Resistance For Specified Plastic Strains.





maintaining specified properties

Chances are you spend hours . . . even days . . . studying the "book" specifications of a metal before you design it into a part. But the book you've been working with too often gets thrown out the window with the first production run. Getting the most out of the premium alloys and into the cast part is often a difficult task, but we feel we're in an ideal position to do just that. Sand, shell, and permanent mold casting the *light metals* . . . and *only* the light metals . . . is our business.

fifty-eight page engineering manual

A considerable amount of data on the design properties of the aluminum and magnesium alloys can be found between the covers of our light metals casting manual. We'll gladly send you a copy on letterhead request. Write Rolle Manufacturing Company, 319 Cannon Avenue, Lansdale, Pa., or call ULlysses 5-1174.

ROLLE

International scene

BY ANDREW G. HALEY

I RECEIVED an invitational visa from the U.S.S.R. Embassy on May 12, 1958, for the purpose of attending the Moscow session of Working Group XI of the International Radio Consultative Committee (CCIR). Working Group XI was scheduled to consider problems in connection with long-range transmission of television. And as the use of satellites as passive and impassive instrumentalities in such transmission have been suggested and advocated by scientists throughout the world, and indeed are on the U. S. program, I thought it was urgent that once again the CCIR should not overlook this scientific problem. I wanted to discuss generally the problem of radio and television in astronautics, and in this informal manner hoped to make the delegates from 34 nations aware of many aspects of astronautical communications.

On May 26, I joined the U. S. delegation at Copenhagen and we traveled to Moscow where we were met at the airport by Z. V. Topuria of the Ministry of Telecommunications and Chief of the U.S.S.R. delegation to the Working Group XI meeting. I was individually met by Academician Leonid I. Sedov, Chairman of the Commission on Astronautics, Academy of Sciences and Vice-President of the International Astronautical Federation, and Dr. Alla Massevitch, Chairman of the U.S.S.R. delegation at the VIII Annual IAF Congress.

On May 28, I attended the plenary session of Working Group XI. In view of the fact that the IAF is a recognized international organization fully accredited to the International Telecommunication Union, I was seated as a principal observer. The three alternative proposals for consideration of astronautical television and a rather complete proposal for the study of the problems were presented to the conference. These proposals and study program provide briefly as follows:

(a) Considering that transmission of television signals between and among earth, earth satellites, space vehicles and positions in space is foreseeable, what practicable measures can be taken to provide for the transmission of television signals in connection with activities in astronautics?

(b Considering that transmission of television signals over extremely long distances in space will be used for a variety of purposes, including, for example, the relaying of broadcast program signals, what will be the categories of uses of such transmission, what are the parameters for signals of each category, and how can standardization of signals be effected to promote the best international usage of such signals in communications, telemetry and guidance?

(c) Considering that transmission of television signals over long distances in space is foreseeable, what are the characteristics of the signal, circuitry and propagation path—how do these characteristics differ as between color and monochrome signals, and what methods of measurement and what test signals can be recommended for checking these characteristics?

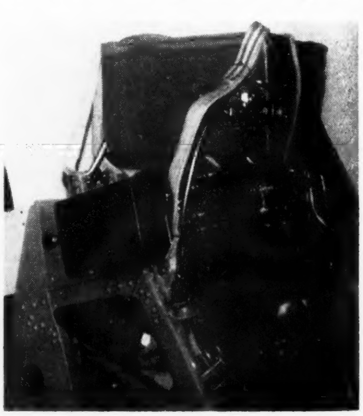
(d) As part of the current Study Program No. 32 dealing with transmissions of television over long distances on earth, a study should be made as to the general requirements for a 405-line, 2000 kc/s video band system for use in the transmission of television signals over extremely long distances between earth and positions and objects in space. The technical matters to be studied under this program would include the input and output impedance of the transmission circuit, polarity of signal, signal amplitude, signal to noise ratio, stability of the overall transmission circuit, etc.

On May 29, Dr. Massevitch took me to the University of Moscow where I was shown all of the installations at the Sternberg Observatory—the astronomical college and center of the University. Professor Dimitry F. Martynov, Director of Sternberg Institute, joined us on the way.

We spent a good deal of time surveying Sputnik tracking equipment and procedures, including the photographic installation, the telescopic equipment and the very interesting platform made available for personal observation by individual scientists. This installation consists of ten booths each equipped with electrical outlet and individual electronic telescope for gathering data by personal observation. Each booth is assigned to a competent scientist. I was advised that the U.S.S.R. has seventy such stations throughout its area plus five more of an unofficial character located at certain universities.

In the lecture hall I was welcomed by an excellent audience who had come to hear the talk I had prepared in Washington, and which was, at my request, translated into Russian without change or deletions.

Following the lecture I had an extended conference with Drs. Sedov and Massevitch. The U.S.S.R. is being host to scores of congresses involving thousands of persons from all over the world, and during 1959 it appears



At Moscow, Andrew Haley (right) is accompanied by Dimitry F. Martynov (left) and Alla Massevitch. Replica of Sputnik II capsule which carried Laika was seen by Haley at Soviet General Agricultural and Industrial Exhibition.

simply unreasonable to hold the IAF Congress in Moscow.

For example, more than 400 persons from the United States alone will attend the Astronomical Congress which will be held in Moscow during August 1958. Hundreds of persons from the rest of the world, of course, will also be present. This places an enormous burden on the Academy of Sciences.

The Academy of Sciences in Moscow is not inclined in any way to decrease the number of congresses, but experience has shown that they must schedule at least three years in advance. Accordingly, the discussion may be summarized by stating that the U.S.S.R. could not possibly hold an IAF Congress until 1962.

According to our present arrangements, if Moscow was not available in 1959, the British Interplanetary Society would take over the X Congress in London, the XI Congress in 1960 would be held in Stockholm, and the XII Congress would be held in Washington, D.C. Thus, Moscow would follow the Washington Congress. This, of course, is a plan—not a promise.

I urged, on behalf of myself and L. R. Shepherd, that Dr. Sedov be a candidate for President of the IAS at Amsterdam this coming August. Sedov said that he is not prepared to assume the office, that he desires me to continue in office for two more years, on the basis of a three-year cycle, and that thereafter he will give serious consideration to accepting the office of President. Dr. Massevitch stated that as a member of the Constitutional Revision Committee she would advocate a provision in the IAF statutes which would permit a person to serve for three continuous years as President.

I reiterated my position that the President should serve for only one year and that I had an honorable obligation not to be available again, in view of the action of Dr. Shepherd in stepping down after one year from the Presidency, and the further action of the British Interplanetary Society in nominating me for the post. This obligation, of course, is above and beyond my own view that the President should not succeed himself.

Friday morning I was accorded a real privilege. A conference had been arranged for me with President Nesmeyanov of the Academy of Sciences and directing head of all U.S.S.R. research and development, including the entire IGY program and the construction and operation of Sputniks. Also present were A. A. Blagonravov, Konstantin Semenov and S. G. Korneev.

President Nesmeyanov stated that a delegation of at least four U.S.S.R. scientists would attend the IAF Congress in Amsterdam and that the names of the delegates and topics of discussion would be furnished as soon as available. We discussed the appointment of Professor Shumoski, a graduate of Massachusetts Institute of Technology and successor to Professor Auger as Head of the Department of Sciences of UNESCO, and the desirability for cooperation between UNESCO and the IAF. We also discussed the problems of defining the limitations of "airspace" and matters in connection with world astronautics.

During the course of the two weeks in the U.S.S.R., on several occasions I had discussed the problems of astronautical communications with the heads of delegations from many nations. I had a concluding conference with E. Metzler, Director of the CCIR, and we arrived at a complete and wholly satisfactory agreement. The documents which were agreed upon and which will be considered by the special staff of the CCIR read: "*Considering:*

(a) the rapid development of rockets in general and of artificial satellites in particular

(b) that transmission of radio signals between the earth and extraterrestrial positions in space is now an established fact

(c) the use of satellites as measuring and observation stations and possibly as relay stations

(d) that extraterrestrial objects may well be consecutively above different countries of the world, thus necessitating international collaboration

(e) that radiocommunication between extraterrestrial objects and the earth will be of utmost importance; "*decides* that the following questions should be studied:

1. what frequencies are specially suitable for penetration of the layers of the earth's atmosphere?

2. what are the influences on these frequencies of the hour of the day, the season, the geographical location and solar activity?

3. what deviations in propagation direction can be expected by the penetration of the ionosphere?

4. what, if any, will be the differences in propagation between in-going and out-going signals relative to the earth?

5. are special phenomena to be expected that do not occur in transmission between two points on earth?

6. what is the possible influence of the troposphere on wave propagation to and from extraterrestrial objects?

"NOTE: Study Group V will consider the tropospheric propagation effects, Study Group VI the ionospheric propagation effects."

Missile Reliability

(CONTINUED FROM PAGE 37)

new test facilities was becoming critical were cryogenics, helium, random and complex waveform vibration, high force vibration, and combined environment plus function. Steps were taken to meet these needs.

Wyle engineered and built, on a 200-acre tract at Norco, Calif., a cryogenics facility for high flow testing with liquid and gaseous oxygen and nitrogen. This facility can produce liquid flows to 8000 gpm and gaseous flows to 40 lb/sec. Equipment includes one 10,000-gal and two 4100-gal lox/liquid nitrogen storage vessels and a 20,000,000 Btu/hr heat exchanger for vaporizing liquified gases. Certified "lox-cleaning" facilities are provided. Protected areas are available for testing solid-propellant engines and components.

A complex helium test system was developed at El Segundo for development, qualification and production testing of regulators, relief valves, storage bottles, and similar components. The system incorporates high pressure helium storage tubes, helium recovery systems, compressor equipment, extreme low temperature heat exchangers, and flow measuring devices capable of recording helium flows up to 60 lb/min. at −300 F. A reinforced concrete test cell is provided for hazardous testing, such as burst tests and vibration and acceleration tests of pressurized components. Typical testing includes acceleration and vibration at 10 g's with helium storage bottles pressurized to 3000 psig at −300 F, and burst tests of helium storage spheres at pressures up to 8500 psig.

A complete vibration system for producing random and complex waveforms includes an MB C-25H 3500-lb exciter, Ling 20/20C amplifier, General Radio random noise generator, and associated data recording accessories and protective devices.

Extremely high force vibration has been achieved in the successful development of the Wyle Hydrashaker, which uses a new principle of electronically controlled hydraulic power originally conceived by Northrop and exclusively licensed to Wyle. The Hydrashaker is said to afford combinations of force, acceleration and frequency not possible with any other single system in production today. For example, it can shake a 3000-lb specimen at 15 g's at 100 cps.

Combined environmental and functional tests can be made at this facility. For example, to test a liquid oxygen valve under conditions of altitude, temperature extremes, vibration and acceleration, a Mantec altitude-tem-

perature chamber would be mounted with a Hydrashaker on a centrifuge for connection of the valve to existing oxygen flow systems. The valve could then be given a rigorous test equal to anything it is likely to encounter in a typical missile flight.

Random vibration has for some time been called for in specifications. Too often, it has had to be neglected. The single-roof concept permits Wyle to make such tests and to perform them under environmental conditions and with the actual fluids that will be used in the missile.

For example, Wyle found that a lox vent valve designed for a flow rate of 36 lb/sec gave almost 100 per cent reliability when tested at a flow rate of only $^1/_2$ lb/sec. Increasing the flow to 4 lb/sec caused seven or eight out of 10 valves to fail. Testing at the more realistic flow rates revealed slight design defects, which were soon rectified. The valve now functions at the full rate of 36 lb/sec.

Cold flow tests, particularly, bring many failures. It is therefore important that all cryogenic components be subjected to actual media tests before being installed in missiles.

Once the word comes to fire, there can be no allowance for faulty components. It will be small consolation to the inhabitants of obliterated cities that we tested but did not test well enough. The single-roof facility may be the answer.

Boron-Based Fuels Show a Little Zip

The Zip program begun in 1951 by the Navy's Bureau of Aeronautics to develop high-energy fuels for jet engines reached a landmark recently with the official start of production at this country's first full-scale boron-based-fuel plant at Model City, N.Y. Built by Olin Mathieson Chemical Corp. for the Navy at a cost of $4.5 million, the plant will turn out the Olin-developed fuel known as HEF-2, which is chiefly pentaborane, alkylated to improve its handling and storage properties.

Adjacent to the Navy plant, Olin is building a $45 million plant for the Air Force that will produce HEF-3, a variation of HEF-2. These liquid fuels give about 25 per cent more heat release and have greater bulk density than typical jet fuels now in wide use, such as JP-4.

Other companies will also produce the Olin HEF line of fuels; but until production capacity becomes considerably greater than that presently expected, boron-based fuels will not be available in quantity for wide operational use by the services. The Navy plans to use its allotment for further development work.

Meanwhile, Olin continues development of the HEF line, with HEF-4 in pilot production and HEF-5 under development. Solid propellants based on boranes are also under development by Olin and other companies, chiefly Callery Chemical.

Russians Reported Testing New Air-to-Ground Missile

The Russians are reported to have flight tested a new air-to-ground ballistic missile with a megaton warhead and an approximate range of 50 miles. Said to be the equivalent of our Rascal, the Soviet supersonic vehicle is propelled by a solid fuel rocket and launched from a four-jet Bison intercontinental bomber at altitudes around 50,000 ft. That no electronic or infrared guidance system has been integrated into the missile is regarded as recognition that USAF electronic countermeasures have advanced to the stage where such guidance systems are of dubious value in operational service.

A report on a micrometeor density test conducted earlier this year by the Russians via a single-stage rocket fired to an altitude of 294 miles up, indicated 268 micrometeor collisions between 78 and 186 miles.

Hughes Fellowships Awarded

Fifteen university students have been awarded Howard Hughes Fellowships to assist them in obtaining a doctoral degree in their scientific specialties. Fellowships cover tuition, research and other expenses, and also provides a salary from Hughes while award winners work in its Culver City research laboratories.

Correction

The photographs of D. M. Tenenbaum and W. Sprattling Jr. of Aerojet-General Corp. on page 28 of the July ASTRONAUTICS were inadvertently transposed. Herewith, the two gentlemen correctly identified:

W. Sprattling Jr. D. M. Tenenbaum

A Look at "Whiskers"

(CONTINUED FROM PAGE 33)

3. Modulus and strength are reduced 20 per cent as a penalty for the weight of nonload carrying binder. This whisker binder or matrix is analogous to the plastic that binds glass fibers in plastic-impregnated fibered glass. Fibers carry most of the tension load, while the plastic is very lightly stressed in shear.

4. Biaxially stressed sheets are composed of two bonded layers of mutually perpendicular fibers, each layer being active only in transmitting the tensile stresses parallel to the whiskers.

The table on page 33 compares calculated properties of whisker material in terms of titanium, a structural material in present day use. The properties of whisker composites, although appearing exceptionally favorable for structures, require some further examination.

Weight estimates of typical tension-loaded structural elements should cover both basic material properties and any peculiarities of the material. For example, sheets of conventional material require doublers wherever the edges are fastened, and this doubler weight should be accounted for, even though it is only a small fraction of the total weight. The problem of fastening to adjacent structures will be far more severe for whisker composites than for conventional materials, with a proportionally larger weight penalty in most instances.

Extra weight of this kind was included in an overall design study of such structural components as cables, biaxially stressed sheets fastened so as to be removable (as in some pressurized vessels), biaxially stressed and permanently fastened sheets (as in spherical vessels and some cylindrical tanks), and components in miscellaneous applications. This study indicated that the weight of tension structures for space vehicles might be reduced to one-fifth if whisker composites could be used in place of presently available materials.

Perhaps the biggest question is whether whiskers can be produced practically in the needed quantities, qualities, and forms. Several techniques have been used in laboratories to grow whiskers—reduction of metal halides by hydrogen or a reducing agent such as zinc; electrolytic deposition of silver, iron, and copper whiskers from a molten salt; deposition from a controlled supersaturated vapor of metals or metallic compounds; high-stress on soft metals (whiskers probably grow from the base and not the tips in this situation); and drawing micron-size filaments from hot metal and fibers of compounds, such as glass from the liquid phase (these materials give considerable strength, though not on the order of whiskers).

We will assume that any of the growing techniques successful in the laboratory can be scaled up to both pilot plant and full scale production under sufficient economic incentive.

It is possible to envisage means for making the growth and collection of whiskers orderly. Alignment, thinness, and length could be controlled by the proper saturations, temperatures, and magnetic or electrostatic fields, and harvesting might be done by vibratory or mechanical scraping techniques.

At this stage, whiskers would be in bundles or mats, held together by sufficient friction and electrostatic forces to prevent unraveling. Spinning of fine strands of whiskers from these agglomerates might be similar to the spinning of textile or glass fibers. Strands could be woven into cable or sheet.

This woven product, still weak in tension because of the lack of bonding between adjacent fibers, could be brought into a final, strong form by at least two processes that can raise the cohesive bond between whiskers—impregnation with a binder, or pressing and heating.

Plastic-impregnated glass fiber is a good example of the first method of imparting good cohesion to filament aggregates. Present cohesive binding plastics such as phenolics, silicones, and polyesters can be used as binders only up to 600 F, but there are hopes that future developments—for example, polymeric boron resins—will extend their usefulness to 1000 or 1200 F. Pressing and heating may prove successful if compacting pressures are low enough not to damage the whiskers.

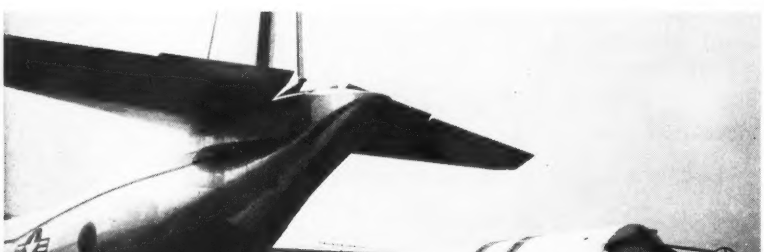
In sum, the production of structural elements, such as sheets and cables, which utilize the strength of whiskers, appears within the future state of the art.

Reduce Weight and Cost

Once whiskers are available, the usefulness of cutting the structural weight of space vehicles up to some 80 per cent can be evaluated either in terms of increased performance or dollar cost compared to dollar value. As to performance, the four-fifths of structural weight saved in each space-vehicle stage could go into propellant or payload. Economically, it is important to establish that the "worth-in-use" of whisker composites will be larger than its eventual cost.

One estimate of the future cost of whisker materials is $200 to $400 per installed pound, which may be compared with about $40 per installed pound for aluminum today. Since one pound of whisker composite can replace up to five pounds of conventional materials, that pound is worth the (saved) cost of four pounds of structural weight. Moreover, the value of saving a pound of structural weight has been variously reported to be between $100 and $1000 in aircraft, and to be even higher for missiles and astronautical vehicles. The worth-in-use of one pound of whisker material thus appears to be $400 to $4000 or even higher.

Since the potential value of whiskers appears considerable both in performance and dollar value, it can only be hoped that a systematic effort will be made in the future to study and exploit them.



Missile-Toting Transport

AF Thor IRBM is being eased into Douglas C-133A Cargomaster, largest U.S. operational military transport, capable of carrying any of our ballistic missiles.

From the patent office

BY GEORGE F. McLAUGHLIN

System Reduces Fuel Rate When Starting Rocket Engine

Liquid-propellant rocket engines of the high output type may explode when starting if fuel flow to the combustion chamber is excessive. A recent invention contemplates a means for controlling the fuel flow in stages, so as to insure reduced flow rate for a few millisec and provide an initial rate of flow in the first stage for starting. The initial step prepares the combustion chamber for full feed flow in the second stage by the use of injector nozzles sealed with blowout plugs, of which only a limited number are permitted to blow out on propellant pressurization.

The rocket shell is closed at its nose end by a wall with a recessed extension adapted to carry a warhead. The shell includes a supply of liquid-fuel propellants, while a combustion chamber in the lower end of the shell communicates with the propellant supply through an injector head. The combustion chamber has a nozzle throat which exhausts to the outside.

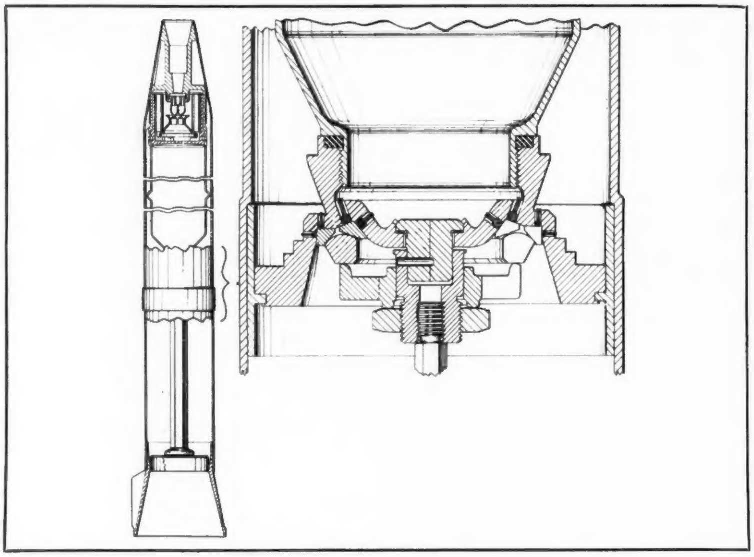
To provide for two-stage fuel flow, the nozzles of the injector head have plugs designed to blow out under the pressure of the pressurized propellants. A retaining ring seals some of these plugs in the nozzles until desired fuel pressure is achieved. These plugs then blow out, providing a minimum flow rate for the first stage of ignition. A blowplug connected to the blocking system seals off the combustion chamber from the exhaust throat. Pressure created by the burning gases during the first stage of fuel flow blows out the throat plug, which in exiting through the exhaust throat, carries along with it the backing arrangement. This action permits the remainder of the nozzle injector plugs to be blown out, providing the full fuel flow rate.

Propellant components of the fuel are contained in the shell. A tank bottle of smaller diameter than the shell is fitted into the shell body. The tank has surface protuberances which butt against the shell wall, keeping the tank a desired distance from the wall. The bottle contains an oxidizer such as nitric acid. The space surrounding the bottle provides a chamber which holds a liquid propellant such as aniline.

In operation, the propellants are pressurized by gases produced by setting off the igniters and causing the solid fuel grains to burn. The pressurized propellants cause the unbacked plugs of the nozzles to blow out, whereupon a minimum or reduced flow of fuel enters the combustion chamber. The increased pressure in the combustion chamber blows out the throat plug and shears a pin holding the hubpiece. The shaft, hubpiece, and backing elements are all blown out along with the throat plug. The parts blown out may be of plastic material to prevent damage to the throat.

Removing the backing permits the remainder of the injector plugs to be blown out, establishing a full flow rate of the propellants. The combustion chamber, having been preheated and with pressure adequately built up by the first stage of operation, is prepared for the full stage of operation, and the danger of the rocket blowing apart with full combustion is eliminated.

The ball plugs blow out at low pressure. This avoids a lag in the full fuel flow following the first stage of operation, whereby the combustion chamber pressure does not drop excessively in transition to second-stage operation.



Cut-away view of two-stage liquid-rocket engine, and an enlargement of central (bracketed) portion showing details and arrangement of injector head in longitudinal section.

Patent No. 2,829,491. Two-stage liquid-fuel rocket. Walter D. Teague, Jr., (ARS member) Alpine, N.J., assignor to Bendix Aviation Corp. (ARS corporate member).

Optical System Gives Sharp Image for Missile Guidance

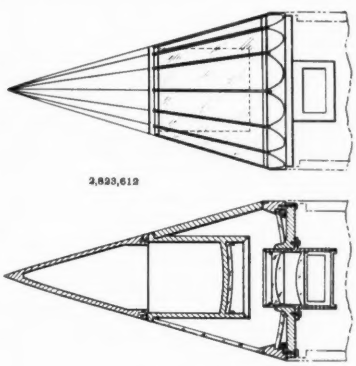
French astronomer Cassegrain in 1672 devised an optical system for telescopes which is now included in a patented target-seeker head for guiding supersonic missiles. In the astronomer's proposal, the light rays are reflected from a concave mirror to a smaller convex mirror, and then through an opening in the concave mirror to the observer's eye. In the present invention, assigned to the U.S. Air Force, the optical system transmits light rays of a target to a focal plane for the control mechanism of the missile.

The seeker head is pyramidal, with several sides. The leading end is opaque and the rear end has flat glass plate windows. Supported on the base of the head, and facing toward the front end, a concave mirror reflects light rays entering the windows from an objective field parallel to the axis of the head to a convex mirror. The mirror reflects the rays through

a barrel which supports lenses for color correction and field flattening.

Baffles on the convex mirror and the barrel prevent direct rays from striking the convex top surface of the color correction lens. The parallel glass plates are joined at their longitudinal edges to thin metal stringers. Edges of the glass plates are reflecting surfaces to eliminate intensity variation around the image field when the head is mounted on a missile directed at a uniformly illuminated area.

When positioned on a missile, the image of any object in a 20-deg cone of view in front of the target-seeker head will appear on the focal plane for scanning by the missile control system. Light rays entering the nose pass through the glass plates and are reflected by the primary concave mirror to the secondary convex mirror. The rays are reflected by the convex mirror through the color-correcting doublet and the field flattener to the focal plane. The baffles prevent direct



light rays from striking the convex mirror and the lens doublet, but allow rays from the concave mirror to pass to the convex mirror.

The stringers ordinarily would cause variation in light intensity around the image field even when the head is directed toward a uniformly illuminated object. Such variation would result in false signals being fed to the missile control mechanism. The shadow effect of the stringers is practically eliminated by silvering the edges of the glass plates. Light transmitted from the terminal edge of the conical forward field of view is reflected from the silvered edge of one of the plates on one side of a stringer with a reflection angle equal to the incidence angle.

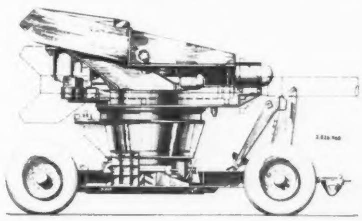
Reflected light passes into the optical system as if it came from the opposite boundary edge of the field of view. The reflecting edge of the adjacent plate on the opposite side of the stringer has a similar effect, except that reflected light appears to come from the opposite side of the field of view. Thus, nearly all light which would be intercepted by the stringers when the missile head is exposed to a uniformly illuminated forward field of view is transmitted into optical system to eliminate shadow effects in the optical image. This keeps false signals from arising when no target is in the field of view.

The doublet corrects chromatic aberrations caused by color dispersion in the light rays through glass surfaces. The field flattener lens merely flattens the image on the focal plane. A clear sharp image with good contrast on the focal plane provides a scanner missile control system with the means for guiding the missile to its target.

Patent No. 2,823,612. Target Seeker Head for Guided Missiles. Arthur Cox, Park Ridge, Ill., and Catherine Ledda, New York, N.Y.

Compact Shipboard Launcher for Missiles

Designed especially for shipboard installation, a newly patented launcher provides a relatively stable platform for launching missiles and rockets. The inventor of the device is assistant chief engineer of the Research Div.,



Side view of missile launcher adapted for use on a land vehicle.

Navy BuOrd, and was chief of the launcher design section for the Polaris.

The launcher is considerably shorter than the missiles it fires, and is easily loaded. Two missiles like the Terrier are supported at a height convenient for operating personnel to make pre-flight inspections, adjustments and repairs. The two missiles can be fired simultaneously or singly.

The launcher may be remotely controlled from the conventional shipboard fire control system.

A launcher of this design was tested on the USS Norton Sound, and then installed on other missile cruisers. Marine Corps missile battalions use a mobile version of the launcher, which is mounted on a wheeled platform instead of a ship deck.

Patent No. 2,826,960. Missile launcher. Ferdinand J. Schiavi, Falls Church, Va.

First Space Flight Training Program to Get Underway

The first U.S. pre-space flight training program, aimed at creating a nucleus of fully-trained men to man future space vehicles, is scheduled to start by late summer at Edwards AFB, Calif. The two-year program will pick specially qualified AF personnel to undergo close simulations of the stresses expected from space flight.

Brig. Gen. Donald D. Flickinger, physician-head of the AF's Directorate of Life Sciences, ARDC, said that "no man will be sent into space until we have successfully carried out a launching and re-entry of an unmanned vehicle, and of a vehicle containing a primate capable of providing data on the physical effects of the flight."

Moving Day at Convair

More than 7000 Convair-Astronautics employees are moving into this new $40 million San Diego plant. Atlas ICBM's will be turned out in the 834-ft long factory in the background.

High-Speed Gliding Vehicle

(CONTINUED FROM PAGE 35)

hot. The maximum temperature generated at its surface during a glide can be estimated by assuming steady-state conditions, because the glider will remain at a certain speed range for a few minutes, and by assuming there is no heat flux within the glider, heat being transferred only by convection and radiation. Radiation from the sun, boundary layer and zone of ionization is disregarded. Calculated temperatures should be higher than those occurring in flight because of neglect of heat flux in the glider and dissociation of air in the boundary layer.

The hottest part of the glider will be the lower side of the wing, which inclines 5 deg more to the air stream than does the bottom of the body.

The reason for the square wing might be mentioned here. With respect to aerodynamic heating, a swept-back wing has certain advantages over a square wing if the leading edge can stay behind the Mach cone that originates at the tip or intersection of the leading edges of the wing sides. But the glider travels much of the time at Mach numbers above 8, where the cone takes on a small apex angle. The wings must consequently be very sharply swept to stay within the cone, and it turns out that a sharply swept wing lacks stability and gives little advantage, from the standpoint of aerodynamic heating, over the square wing, which has good stability.

Turbulence and wing loading affect aerodynamic heating. A full-scale glider 80 ft long with a wing loading of 10 lb/sq ft would, along a path for L/D_{max}, experience laminar flow over its total length at Mach 10 and above. Turbulence at lower Mach numbers would not, moreover, increase surface temperature beyond 1400 F. Increasing wing loading increases heating directly and shifts the transition from laminar to turbulent flow to a shorter distance from the leading edge of the wing, thus increasing extensively the area reaching high temperatures.

Maximum wing temperature occurs when the glider has 10,000 nautical miles to go after leaving an orbit for earth. The wall temperature at satellite speed would be lower because of lower air density at higher altitudes.

If a stick-fixed glider only 2 ft long remained stable at a wing loading to angle of attack ratio of 6 lb per sq ft/deg, it should, starting at satellite speed, reach a maximum wall temperature of 2200 to 2300 F.

A 2-ft-long glider, like the one shown on page 34, actually exists. Of stainless steel and weighing 5 lb, it is equipped with a device that actuates on water impact and floats the glider for about 6 hours. It would be useful for initial tests. Recovery of this small type of glider from a satellite orbit, however, would require ground impact.

Turning now to stability, we find that requirements differ for stick-fixed and controlled gliders.

Laterally stable motion is possible for the fixed-stick glider at small lift coefficient which are equivalent to small angles of attack. The restoring moments of the vertical and horizontal tail will give longitudinal stability if they are large enough. This leads to placing the tail as far aft of the CG as possible. Lateral stability may be improved if the CG is under the supporting wings, as shown on the flat-topped model. Gliding tests in water at small angles of attack have proved the inherent longitudinal and lateral stability of the flat-topped model without a rudder on the underbody.

The lift-drag ratio of the flat-topped configuration should be somewhat less than that of the flat-bottomed configuration at equal lift coefficients. Free-flight tests will show which of the two configurations can glide stably at higher altitudes with less aerodynamic heating. Free-flight tests will also show whether use of a rudder at the lower side will improve stability. Theoretically, the rudder is not needed for stick-fixed glides.

Servo Replaces Pilot

Classical aerodynamic theory requires an aircraft to be dynamically stable in both the stick-fixed and stick-free cases. This is not necessary with an adequate servomechanism control pilot. For the supersonic glider, we find that a human pilot cannot exert effective control. A good servomechanism, on the other hand, will overcome all stick forces. With an automatic pilot, then, neutral stability in the stick-fixed flight will insure stable flight and the classical requirement for stick-free stability can be disregarded. A human pilot might, of course, give pitch and yaw directions, but the servo controls would perform them.

A new form of control system can be recommended if a fast acting servomechanism will pilot the glider. This control system would be characterized by the following:

1. A wing with no ailerons, both semispans being adjustable instead. The outer wing experiences more lift during a turn. It seems more logical to reduce the angle of attack of the total outer semispan than to operate ailerons, which cause adverse yaw. Wing adjustment for this kind of glider amounts to less than a degree.

2. Rudder below the body axis and through the CG. This would avoid adverse roll that might occur with the rudder conventionally placed above the axis. Desired glider azimuth would be maintained through rudder control.

3. Air brakes at the wing tips, to be operated when necessary. These would permit yaw control without adverse roll.

4. Three independent servomechanisms for controlling pitch, roll, and yaw. The one for pitch maintains the body axis in reference to the horizon by deflection of the horizontal tail; the one for roll maintains the glider Y-axis in the apparent perpendicular by semi-span deflection; and the one

Letting Off Steam

Water-cooled detuner is used to silence exhaust roar from de Havilland Spectre liquid-propellant rocket engine during a ground check at Boscombe Down, England. Steam pours out of end at right.

for yaw prevents side-slip (determined from static-pressure differential equidistant from the CG along both sides of the body or, alternatively, from yaw velocity and acceleration). The deviation from the desired value and its first derivative with time—preferably both—would be used for power operation of the control surfaces.

This guidance equipment would have to be air-conditioned for 1.5 hours for one full circuit of the world by the glider.

We should look, finally, at a few points concerning launching, tracking, and recovery.

Ground-Launching Conditions

Considering only ground launching (balloon launching is also possible), a stick-fixed glider must meet certain conditions at the moment of its separation from the booster used. These are:

1. Altitude and Mach number must be coordinated for the desired wing-loading/angle of attack ratio.
2. Glider must be given an approximately horizontal flight path (preferably 1 deg downwards) and desired angle of attack and azimuth must be maintained.
3. No excessive angular accelerations must be imparted in pitch, roll, and yaw.
4. The glider must be covered by an expendable hood during ascent. Discarding the protective hood and firing vernier rockets to bring the booster, with the exposed model, in to the desired flight altitude might cause some trouble because of the vibrations induced.

Moreover, gliders with guidance will be considerably larger and heavier than stick-fixed models. Thus the wings of a big glider with guidance will, in particular, extend beyond the contour of the booster. The booster will consequently need powerful vernier rockets or aerodynamic control surfaces, or both, to keep the ascending vehicle on the desired path.

Optical tracking of small, model gliders should be easy because they will glow white and red. Impact or landing point can be calculated from the first optical observations. Radioactive tracers may aid in finding the landing place.

Larger guided gliders could be equipped with a transmitter, and possibly even with a mechanism for recovery in water, as the landing speed of a guided model at sea level should be about 100 mph for a wingloading of 10 lb/sq ft. This equipment, however, including guidance, must be air-conditioned against 2000 F ambient temperatures. Elimination of the air-conditioning problem makes the stick-fixed model attractive.

Government contract awards

Boeing, Martin-Bell Teams Get Dyna-Soar Contracts

The AF has awarded contracts for development of Dyna-Soar to teams headed by Boeing and Martin-Bell. In announcing the first major awards for a new space vehicle since the Russian Sputniks were launched last fall, AF officials said the two teams would compete during the initial development phase of the project, with one chosen later to produce the manned boost-glide vehicle.

The Boeing team includes Aerojet, Chance Vought, North American, Ramo-Wooldridge and GE. The Martin-Bell team includes AMF, Bendix, Goodyear and Minneapolis-Honeywell.

Goodyear Gets $65 Million Pact To Build Navy's Subroc Missile

The Navy has awarded a $65 million contract to the Goodyear Aircraft Corp. to develop the Subroc, a rocket-powered submarine killer missile designed for launching from a submarine on or below the surface.

Ion Propulsion Contract To Vitro Laboratories

The Air Force has awarded a research contract to Vitro Labs, Div. of Vitro Corp. of America, to investigate possible applications of the high intensity electric arc to ion propulsion. The program will be directed toward ion propulsion engine types with exhaust velocities between those obtained by high voltage acceleration of low current ion beams and those generated by chemical fuels.

Space Capsule Studies Okayed

ARPA has authorized AF contracts totaling $400,000 for the study of the problems of housing a man in a space capsule over long periods.

Lockheed Gets $7.5 Million Contract for Target Missiles

The Army has let a $7.5 million pact to Lockheed Aircraft for a new Mach 2 recoverable target missile called the Kingfisher.

Siegler Corp. to Produce Mace, Regulus Equipment

Siegler Corp. has been awarded a $560,420 add-on contract by The Martin Co. to produce additional magnetic amplifier autopilots for the Mace missile, and a substantial contract for production of air speed-height simulators for the Regulus II from Chance Vought.

Sperry to Develop, Build Flight System for F8U-3

A $3 million contract to develop and produce all-altitude flight control systems for the Navy's F8U-3, an advanced all-weather fighter under development by Chance Vought Aircraft, has been awarded by CV to Sperry Gyroscope Co.

Army Awards R&D Contract

The Army Signal R&D Laboratory, Ft. Monmouth, N.J. has awarded a $2,634,000 contract to Sylvania Electric Products for a continuation of development work in electronics. No further details as to the kind of work to be done were given.

Telecomputing Gyro Award

Telecomputing Corp. has received a $623,000 contract from Boeing for floated rate gyros to be used in the AF's Bomarc missile.

Thiokol Gets R&D Contract

An Army contract for R&D work on the Nike-Hercules booster engine has been awarded to Thiokol Chemical Co.

Navy Orders Computers for Regulus

Burroughs Corp. has received a $1.7 million subcontract from AC Spark Plug Div. for the design and fabrication of prelaunch data computers for the Navy's Regulus II missile.

SYNOPSIS OF AWARDS

The following synopsis of government contract awards lists formally advertised and negotiated unclassified contracts in excess of $25,000 for each Air Force, Army and Navy contracting office:

AIR FORCE

AFCRC, ARDC, USAF, Laurence G. Hanscom Field, Bedford, Mass.

Research and development of pressure measuring devices for high altitude balloon-borne systems, $55,665, **Victory Engineering Corp.**, P.O. Box 573, Union, N.J.

AF Flight Test Center, Edwards AFB, Calif.

Data transmission system, $62,543, **Electronic Engineering Co. of Calif.**, 1601 E. Chestnut Ave., Santa Ana, Calif.

AF Missile Test Center, ARDC, USAF, Patrick AFB, Fla.

Increase in funds, $50,000, **Radiation, Inc.**, P.O. Drawer 37, Melbourne, Fla.

Increase in funds, $73,116, **Technitrol Engineering Co.**, 1952 E. Allegheny Ave., Philadelphia 34, Pa.

Installation of ROTI Mark II, $130,736, **Perkin-Elmer Corp.**, Norwalk, Conn.

ARMY

CG, U.S. Army Ordnance Missile Command, Army Rocket and Guided Missile Agency, Redstone Arsenal, Ala.

Nitric acid, red fuming type IIIA, $191,093, **General Chemical Div., Allied Chemical and Dye Corp.**, 40 Rector St., N.Y. 6, N.Y.

Corps of Engineers, Office of the District Engineer, U.S. Army Engineer Dist., Tullahoma, Tenn.

Furnishing and installing controls and instrumentation, Phase II, for the supersonic circuit, propulsion wind tunnel, Arnold Engineering Development Center, Tullahoma, Tenn., $293,544, **Shelby Electric Co., Inc.**, 112 E. E. H. Crump Blvd., Memphis, Tenn.

District Public Works Office, 11th Naval Dist., San Diego 32, Calif.

Construction of Regulus II facilities, NAMTC, Point Mugu, Calif., $1,413,989, **L. F. Stilwell & Co., Inc.**, 8230 Beverly Blvd., Los Angeles, Calif.

HQ., Quartermaster Research and Engineering Command, U.S. Army, Natick, Mass.

Tents, missile checkout of Redstone lightweight system, $25,604, **Colonial Aircraft Corp.**, Box 250, Sanford, Me.

San Francisco Ordnance Dist., 1515 Clay St., P.O. Box 1829, Oakland 12, Calif.

Test vehicle rocket engine, igniter, $65,420, **Aerojet-General Corp.**, Solid Rocket Plant, Sacramento, Calif.

U.S. Army Electronic Proving Ground Procurement Office, U.S. Army Signal Supply Agency, P.O. Box 748, Fort Huachuca, Ariz.

Rockets, solid propellant, $67,500, **Grand Central Rocket Co.**, P.O. Box 111, Redlands, Calif.

U.S. Army Engineer Dist., Los Angeles Corps of Engineers, 751 S. Figueroa St., Los Angeles 17, Calif.

Conversion to Hercules at special AAA site, $97,000, **Price-McNemar Construction Co.**, 13726 Saticoy St., Van Nuys, Calif.

U.S. Army Engineer Dist., New England, Corps of Engineers, Portland

Area, P.O. Box 977, Portland, Me.
Construction of missile facility, Presque Isle AFB, Presque Isle, Md., estimated $6,814,744, **J. R. Cianchette, 120 Main St., Pittsfield, Me.**

U.S. Army Engineer Div., New England, Corps of Engineers, Providence Area, 187 Westminster St., Providence 3, R.I.

Construction of missile facility, Otis AFB, Falmouth, Mass., $8,560,445, **Blount Brothers Construction Co.,** 79 Commerce St., P.O. Box 949, Montgomery, Ala.

U.S. Army Engineer Dist., Norfolk, Corps of Engineers, Foot of Front St., Norfolk 1, Va.
Conversion for Hercules, special AAA site, $124,825, **Carter Contracting Co., Inc.,** 106 W. Olney Rd., Norfolk, Va.

U.S. Army Engineer Dist., Pittsburgh, Corps of Engineer, 925 New Federal Bldg., Pittsburgh 19, Pa.
Hercules conversion and elevator improvements at launching area, sites, $378,-888, **The Shaw-Comer Corp.,** 7016 Euclid Ave., Cleveland, Ohio.

U.S. Army Ordnance Dist., Los Angeles, 55 S. Grand Ave., Pasadena, Calif.
Study regarding igniters, $39,905, **Redel, Inc.,** 220 N. Atchison St., Anaheim, Calif.
Work regarding Zebra III, $288,185, **Rheem Mfg. Co.,** 9236 E. Hall Rd., Downey, Calif.
Furnishing and delivering of depot replenishment Corporal missile repair parts, $1,662,346, **Gilfillan Bros. Inc.,** 1815 Venice Blvd., Los Angeles 6, Calif.
Dart rocket motors and igniters, $60,-515, **Grand Central Rocket Corp.,** P.O. Box 111, Redlands, Calif.
Rocket engines, $30,000, **North American Aviation, Inc.,** 6633 Canoga Ave., Canoga Park, Calif.
New solid propellant missile systems test facilities, $241,172, **Aerojet-General Corp.,** Azusa, Calif.
R&D work at Army's Jet Propulsion Lab, $877,751, **Cal Tech,** 1201 E. California St., Pasadena, Calif.
Corporal missile repair parts, $1,175,-205, **Firestone Tire & Rubber Co.,** 2525 Firestone Blvd., Los Angeles 54, Calif.
Rocket engines, $1,656,500, **North American Aviation, Inc.,** 6633 Canoga Ave., Canoga Park, Calif.
Study regarding turbulence theory, $42,299, **Kaman Aircraft Corp.,** 2013 Ridgecrest Dr., S. E., Albuquerque, N. Mex.
Research and development, and engineering services for the Sergeant guided missile system, $791,413, **Sperry Rand Corp.,** Utah Engineering Lab., 322 N. 21 W., Salt Lake City, Utah.
Nike missile repair parts, $145,945, **Douglas Aircraft Co., Inc.,** 3000 Ocean Park Blvd., Santa Monica, Calif.
Engineering studies, analysis and design of airborne instrumentation, $100,-000, **Motorola, Inc.,** Western Military Electronics Center, 8201 E. McDowell Rd., Phoenix, Ariz.
Research and development study reports, $53,462, **Aerophysics Development Corp.,** Santa Barbara, Calif.
Study regarding atmospheric effects, $29,832, **Aeronutronic Systems, Inc.,** 1234 Airway, Glendale, Calif.

U.S. Army Signal Supply Agency, 225 S. 18 St., Philadelphia 3, Pa.
Additional drones and related equipment, $2,352,177, **Radioplane,** Van Nuys, Calif.

U.S. Atomic Energy Commission, Idaho Operations Office, P.O. Box 1221, Idaho Falls, Idaho.
Initial engine test modifications, aircraft nuclear propulsion project at National Reactor Testing Station in Idaho, $316,019, **Watkins Construction Co.,** Boise, Idaho.

NAVY

Dept. of the Navy, Office of Naval Research, Washington 25, D.C.
Mid-atmosphere rocket research, $42,-671, **New Mexico College of Agriculture and Mechanical Arts,** State College, N. Mex.
Research on radiation-induced free radicals of short lifetime, $26,000, **Stanford University,** Calif.

Navy Dept., Bureau of Ordnance, Washington, D.C.
Fabrication and delivery of 120 persons ejection rocket catapults, $108,600, **Talco Engineering Co.,** Hamden, Conn.

Puget Sound Naval Shipyard, Bremerton, Wash.
Spare parts for missile launching system, $42,276, **Sargent Engineering Corp.,** 2533 E. 56 St., Huntington Park, Calif.

Large Astrodyne Booster Uses Extruded Ammonium Nitrate

Astrodyne has announced the first successful aircraft launching of the 130,000-lb thrust XM-34 booster, which is being developed under an AF R&D contract awarded early in 1957. The booster employs a bundle of extruded ammonium nitrate-base solid-propellant grains.

The booster has been successfully static-fired over the initial-temperature range of −75 to 170 F. It must meet these firing conditions after exposure to vibration, salt spray and high humidity.

Astrodyne met a requirement for identifying line-of-thrust of the booster closely by designing a device that can measure line-of-thrust within 1/12 deg. Line-of-thrust must be known to air-fire the booster without upsetting the aircraft.

Japan to Begin Production Of Missiles in Fiscal 1961

Tokyo—Japan expects to start mass production of rocket missiles in fiscal 1961, with air-to-air antiaircraft rockets being given top priority in the Japanese missile program.—**R.L.**

Underground ICBM Base

Here in cross-sectional view is a typical underground ICBM base in the U.S. strategic missile defense system as conceived by an artist for Kaiser Aluminum & Chemical Corp. Shown are: (1) Personnel access; (2) liquid fuel transport; (3) liquid fuel intake; (4) static test area; (5) missile transport; (6) personnel access; (7) living quarters and storage; (8) liquid fuel storage; (9) control room; (10) power generation; and (11) warhead loading.

Plastics for Rocket Engines

(CONTINUED FROM PAGE 27)

because of a combination of chemical inertness, fuel resistance, moderate temperature resistance and good electrical insulating properties.

Flexible thin-wall tubing of nylon can be used for pneumatic and hydraulic lines of liquid engines. The resilience and flexibility of such tubing eliminate prebending and allow blows which might crush or deform metal tubing. Nylon tubing $^{1}/_{4}$ in. in OD and $^{5}/_{100}$ in. in wall thickness withstands a pressure of 3800 psi at room temperature, 2300 psi at 160 F, and 7000 psi at −300 F. Moreover, it has excellent corrosion resistance compared to metal tubing.

Vinyl plastisols, silicones, polyurethanes and many other plastics are employed as potting compounds for connectors, plugs and some control equipment associated with liquid engines. Increasing emphasis is being placed on potted or encapsulated wiring to improve the reliability of engine control systems under severe environmental conditions.

Many problems have yet to be solved in the use of thermoplastics for liquid engines of the future. As the trend in liquid propellants changes from lox and JP fuels to such chemicals as hydrazine, nitric acid, and fluorine, plastics will have to be developed that have, for instance, long-term compatibility with these reactive propellants without dimensional change or gross change in physical or mechanical properties.

Solve Vapor Permeability

Teflon and Kel-F, it might be mentioned, although inert to most propellants, will transmit the vapor of such oxidizers as fuming nitric acid and concentrated hydrogen peroxide after a certain period of time. Vapor permeability is just one of the problems in need of solution. To be sure, the liquid engine utilizing the exotic propellants can be made to work even without new plastic materials by employing different designs, but the price in weight and cost may be high.

Let's look now at structural plastics, which are a combination of a thermosetting resin and a reinforcing material, such as glass, asbestos, metal powder or other inorganic filler. The commonest reinforcing agent has been glass in such forms as mat, fabric or roving. The composite may be anywhere from 60- to 80-per cent reinforcement, depending on the application. The average density of a reinforced part is approximately 1.8. Such light material with high strength can

be extremely advantageous in rocket structures where weight is critical. Epoxy resin-glass fabric compares in compressive strength with some important structural metals as shown in the graph on page 78.

There are several methods for fabricating structural parts. The still widely used original, or hand-layup, method consists of impregnating precut sections of glass fabric with a suitable catalyzed resin (polyester, phenolic, epoxy or silicone) and laying it by hand over a male tool. A plastic or rubber film bag is then placed over this layup, hooked to a vacuum pump, and evacuated. The evacuated bag is then placed in an oven and cured. If precision surfaces are needed on both sides, matched metal molds are used instead of the vacuum bag.

Another method is to impregnate glass fabric with a suitable resin and catalyst, only partially cure it, and then macerate and chop it into pieces about $^1/_4$ to $^1/_2$ in. square. These are placed in a metal mold and compressed with heat and pressure.

Strength from Filament Winding

The highest strength parts have been obtained through filament winding, which typically uses an epoxy resin-impregnated glass roving wound either circumferentially or helically over a mandrel. Cured structures made in this manner have had hoop strength in excess of 200,000 psi and flexural strength of about 6 million.

This process is currently employed in the fabrication of liquid-propellant thrust chambers. Filament-wound structures have also been made successfully for air, nitrogen and helium pressure vessels. These vessels require a thermoplastic or rubber liner, since the plastic-glass structure by itself tends to be somewhat porous under high pressure. Another application for reinforced plastic parts is high-temperature ducting, as for a turbine exhaust. Epoxy resins have been used to great advantage in these parts. Of all the thermosetting resins, they give the strongest, most easily fabricated structures when combined with suitable reinforcing agents. The graph on page 78 shows the strength to temperature relationship of several typical glass-resin systems.

Although reinforced structures of high strength have been fabricated and tested, several limitations to their widespread usage remain. The elastic-modulus of these structures, although high when compared to other plastics, is still very low in relation to metals, and is somewhat of a hindrance in design and fabrication of relatively large structures. Also, little is known about

their fatigue and creep properties.

The making of reinforced plastics began as a hand operation. With the advent of automatic presses and equipment such as filament-winding machines the processes began to become more mechanized. However, one of the prime requirements of a liquid rocket engine is reliability. This means better inspection methods will have to be developed for reinforced plastic structures to assure high quality parts, and a degree of quality control on raw materials that manufacturers of materials have to date not found necessary for other users.

The most commonly used insulating materials in rocket application are plastic foams—phenolics, polyurethanes, silicones and polystyrenes. The insulating ability of foams derives both from the low thermal conductivity of the plastic and the entrapped gas. Extremely light (2 to 20 lb/cu ft), these foams are used where the surrounding equipment has to be protected from the extreme heat of turbines, gas generators or manifolds. They are also used as insulation for propellant tanks or lines carrying cryogenic liquids.

Foams Versatile

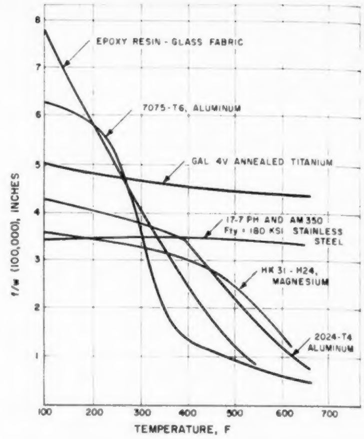
There are two general types of foams, prefoamed and foam in place. The former is formed in standard molds, cut to shape and faced with a suitable metal or plastic skin, and then fastened to the structure. The foam-in-place materials are fabricated directly on the structure by placing the liquid polymer, catalyst and foaming agent in the closed cavity and applying heat. This helps me in getting the material into inaccessible regions.

In the recent literature, fantastic claims have been made for the heat resistance of some plastic materials, with mention of withstanding temperatures up to 10,000 F. Whenever the heat resistance of a material is investigated, it is of the utmost importance to state all the parameters of time, temperature, geometry, velocity and nature of the heat source. Organic plastics deteriorate at about 700 F or lower, given sufficient time. It is true that certain plastics reinforced with inert materials have been successfully used as thrust-chamber liners and as jet vanes for both liquid- and solid-propellant engines at temperatures over 6000 F.

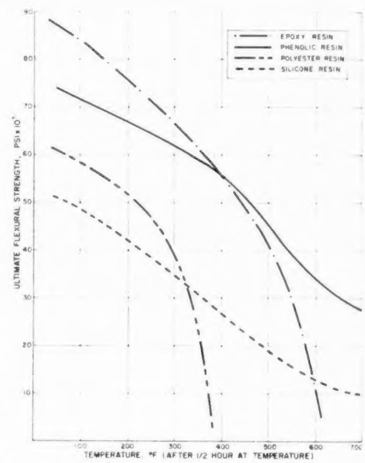
Successful high-temperature service of reinforced plastics has derived from (1) extremely high pressure fabrication methods that give high-density material with no voids; (2) orientation of the reinforcing filaments, so that they can be perpendicular to the direction of the hot gas stream, preventing the peeling off of the layers of plastic and reinforcement and inducing instead a gradual ablation of individual filaments; and (3) resin systems and reinforcement that release low molecular weight gases on decomposing, thus taking advantage of the heat of vaporization. Reinforced plastics that have been successfully used are melamine-glass, phenolic-glass and phenolic-asbestos materials. These materials depend for successful use on exposure time being relatively short, from a few seconds to several minutes.

Widely conflicting data exists on heat-resistant plastic materials, owing mainly to the manner of testing and secondarily to variables in fabrication. The most pressing problem in this field is the establishment of a reliable high-temperature standard laboratory test giving results that can be extrapolated

Representative Structural Properties of Important Plastics



Compressive strength/density vs. temperature of several materials



Representative flexural strengths at elevated temperatures for various thermosetting resins on style 181 glass fabric

to service performance of end items.

There are countless applications for plastic parts in liquid-propellant rocket engines. However, to further the utilization of plastics and to further the progress of liquid engine technology, it becomes extremely important to use plastic parts only where they are needed and where they alone can give the best performance.

The plastics industry can aid the cause of liquid-propellant rocketry by producing better, more versatile polymers and reinforcing materials and by developing extremely reliable manufacturing, test and inspection methods for their products. These efforts will help assure high reliability for liquid engines employing plastic parts.

---

36 Rockoons Launched In Six-Week Period

The IGY National Committee has announced that 36 Rockoons were launched in the Atlantic, Pacific and Antarctic areas from the Navy icebreaker USS Glacier from Sept. 26 to Nov. 9, 1957, as part of the US-IGY program. Of the total, 20 were normal flights, reaching summit altitudes of 105–135 km; 7 did not fire; 2 performed erratically; and 7 were lost.

The vehicles used were 8 ft $3\frac{11}{16}$ in. Hawk Rockoons, consisting of a modified Loki II solid propellant unit and a cylindrical payload 3–$3\frac{1}{2}$ in. in diam, 38 in. long and weighing from 8–9.5 lb. The rockets were fired by a barometric pressure switch when the 26,000-cu ft plastic balloons reached an approximate altitude of 23 km.

Some of the flight data read and reduced, thus far, indicate that total cosmic ray intensity at upper atmosphere levels in high southern latitudes is within 5 per cent of that in high northern latitudes, and about 4.3 times as great as that near the equator. Also, during the present period of high solar activity, the latitude knee is found at a latitude lower than 50 deg. S.

Measurements of the intensity of the terrestrial magnetic field to altitudes over 120 km in the region of the equatorial electrojet indicate an irregular, larger-than-normal decrease of 135 gammas in total magnetic intensity, within the altitude range 97–121 km at 0 deg latitude. The absolute accuracy of each of a large number of measurements in this region is + 5 gammas. Flight data on other experiments, such as three successful magnetometer flights, have not yet been reduced.

In Print

(CONTINUED FROM PAGE 16)

club would be a better audience for him than the world at large. We can however, be grateful to him for sticking his neck out and showing what a high-ranking air force officer thinks about these things. —A.A.

BOOK NOTES

Companies and individuals seeking information on how to obtain missile contracts and subcontracts will find the "**Missile Contracts Guide**" (179 pp., Washington Missile Contracts Reports, $15) a helpful handbook. This large-format volume, made up of material available elsewhere but not previously assembled in this fashion, provides a simple (perhaps too simple) explanation of what a missile is, data on how to obtain Army, Navy, and AF contracts and subcontracts and subcontracts from two prime contractors (Martin Co. and Chrysler), a missile directory, a "who's who" of the missile program in Washington, an alphabetical listing of rocket and guided missile manufacturers, and a glossary of missile and astronautical terminology.

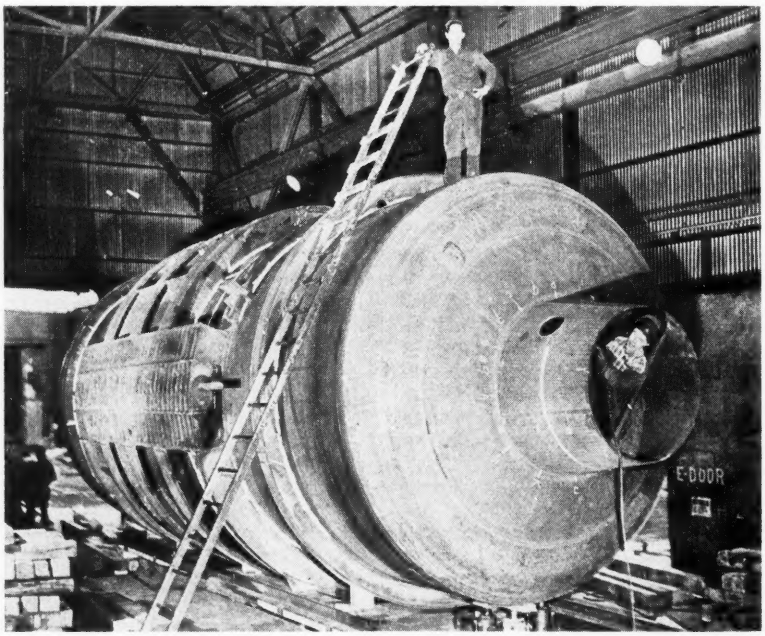
"**Atlas of the Sky**" (St. Martin's Press, New York, $12.50) is just what its title implies—a series of 36 plates which are literally maps of the heavens. In the plates, the stars are depicted as white spots on a black ground, with their sizes graded according to apparent brightness. The accompanying text contains charts showing the boundaries of individual constellations and names or designations of the principal stars, along with descriptive matter relating to a particular subject represented on the plate or suggested by it in some way. The collected texts offer almost a complete course in modern astronomy. This handsome, large format volume, which has already garnered a number of honors for the author, Vincent de Callatay, in its original Belgian edition, deserves a place of honor on the shelf of any enthusiastic amateur or even professional astronomer.

"**The Tree of Mathematics**" (400 pp., The Digest Press, Pacoima, Calif., $6), written by 20 mathematicians and edited by Glenn James, is, as the preface explains, a response to requests for source material from two classes of people—engineers and scientists who need an ever increasing knowledge of mathematics on their jobs, and others who have gone little beyond arithmetic and either want or need to know a little more about math. The volume should prove helpful to both these groups, since it presents the epitomes of the main branches of the subject, beginning with high school algebra and extending far into graduate work. Subjects covered include elementary theory of numbers, games theory, elementary topology and the calculus of variations, among many others. A check of the index reveals that, by looking up a specific topic, page references can quickly be found where the topic is discussed or its meaning depicted by usage. Sum-up: A handy mathematical guide.

"**A Handbook of Space Flight**" by Wayne Proell and Norman J. Bowman (Perastadion Press, Chicago, $6.50) is a hodgepodge of miscellaneous information about astronautics and related subjects. It ranges all the way from properties of the elements to a list of societies devoted to rocketry and space flight, pausing en route to consider such abtruse subjects as flying saucer sightings and colored pyrotechnic smokes. Amply illustrated with graphs, charts and drawings, the volume is hurt to a considerable degree by its failure to give references for a majority of the material it contains. Its accuracy may perhaps be judged by the fact that its rundown on ARS gives a membership count which is about four years old. —I.H.

"**The World in Space—The Story of the International Geophysical Year,**" by Alexander Marshack (176 pages, Thomas Nelson and Sons, $4.95), is an account of scientific studies underway in IGY. The reader is introduced to major areas of study—the Seas of Water and Ice, the Ocean of Air, the Solid Earth, the Sun, etc.—with some background of their investigation, the state of present knowledge, and how they are being studied in the IGY. The book concludes with a discussion of the use of satellites. Directing himself to the uninitiated, the author develops these subjects in a simple, illustrative way. The book should please someone wishing to brush up his "general science" and acquaint himself with the purposes and scope of IGY. The numerous illustrations are good.

"**What Makes Guided Missiles Tick!**" by Barron Kemp (American Electronics Co., 95 pages, $1.50) purports to be "the fascinating story of guided missiles and satellites in simple, every day language." Actually, it is little more than another hastily written, and already outdated, attempt to cash in on public interest in the subject. Unfortunately, it adds little, if anything, to what has already been said on the subject. —J.N.



Nuclear Engine Test Chamber

Nuclear-powered aircraft engines will eventually be tested in this massive 160-ton, 40-ft-long and $12^1/_2$-ft-diam chamber at Connecticut Aircraft Nuclear Engine Laboratory. The chamber, built of Lukens lightweight T-1 alloy steel, can contain pressures as high as 250 psi.

NAA Readying B-70 and X-10 Programs for Flight Tests

Preparations are underway at North American Aviation's missile test facility at Cape Canaveral for flight-testing the X-10 recoverable flight research vehicle and the gathering of aerodynamic and environmental data for SAC's B-70 bomber. The B-70 project is known as Project Rise (Research in Supersonic Environment), with findings to be applied to the B-70 and other manned and unmanned weapon systems. The X-10 will be used as a supersonic drone to test the effectiveness of various interceptor missiles under simulated combat conditions.

Survey Education Needs In Human Factors Area

George A. Peters of the University of Southern California and Joseph L. Seminara of New York University have completed an investigation concerning current academic training needs in the field of human factors engineering. Preliminary results indicate a need for development of more specially designed human factors courses in our universities. They recommend that such courses be less academically oriented and more concerned with providing technological knowledge and skills, and fostering better understanding of systems engineering and operational analysis.

—Grover J. D. Schack

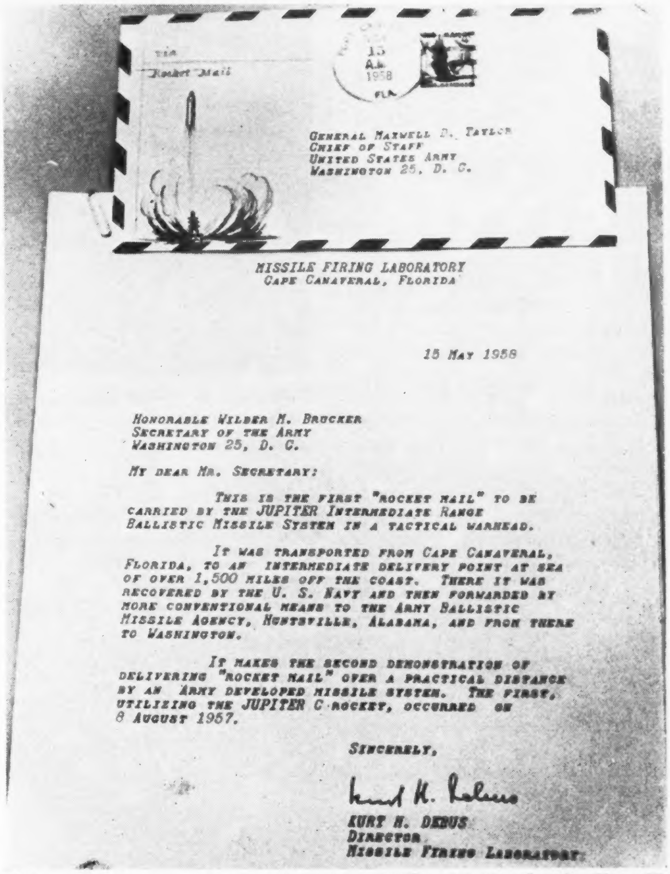
New Wind Tunnel Built By Space Technology Labs

A new, small Mach 3 variable density research wind tunnel has been built by Ramo-Wooldridge's Space Technology Labs. Div. for carrying out magnetoaerodynamic boundary layer research studies for the AF Ballistic Missile Div. The facility, which cost less than $50,000, is built in three sections—a 16 by 32 ft building containing the tunnel test section and instrumentation; a horizontal vacuum tank 16 ft long and 7 ft diam; and a vertical dry air storage tank 25 ft high and 9 ft in diam. Tests can be conducted at a wide speed range, varying from subsonic speeds to more than Mach 3.

Mars Photos to be Taken On Navy Balloon Flight

The Navy has disclosed plans to photograph Mars in the course of a balloon flight to 80,000 ft in November. The flight will be made by two men occupying a sealed cabin on which a 16-in. telescope will be mounted.

Rocket Mail Via Jupiter



Via
Rocket Mail

General Maxwell D. Taylor
Chief of Staff
United States Army
Washington 25, D. C.

MISSILE FIRING LABORATORY
CAPE CANAVERAL, FLORIDA

15 MAY 1958

HONORABLE WILBER M. BRUCKER
SECRETARY OF THE ARMY
WASHINGTON 25, D. C.

MY DEAR MR. SECRETARY:

THIS IS THE FIRST "ROCKET MAIL" TO BE CARRIED BY THE JUPITER INTERMEDIATE RANGE BALLISTIC MISSILE SYSTEM IN A TACTICAL WARHEAD.

IT WAS TRANSPORTED FROM CAPE CANAVERAL, FLORIDA, TO AN INTERMEDIATE DELIVERY POINT AT SEA OF OVER 1,500 MILES OFF THE COAST. THERE IT WAS RECOVERED BY THE U. S. NAVY AND THEN FORWARDED BY MORE CONVENTIONAL MEANS TO THE ARMY BALLISTIC MISSILE AGENCY, HUNTSVILLE, ALABAMA, AND FROM THERE TO WASHINGTON.

IT MAKES THE SECOND DEMONSTRATION OF DELIVERING "ROCKET MAIL" OVER A PRACTICAL DISTANCE BY AN ARMY DEVELOPED MISSILE SYSTEM. THE FIRST, UTILIZING THE JUPITER C ROCKET, OCCURRED ON 8 AUGUST 1957.

SINCERELY,

Kurt H. Debus

KURT H. DEBUS
DIRECTOR
MISSILE FIRING LABORATORY

This letter was sent to Army Secretary Wilber M. Brucker by Kurt H. Debus, director of Cape Canaveral Missile Firing Lab., in nose cone of Jupiter during a recent successful firing.

ECRC Research Review

The 1957–59 edition of the Engineering College Research Review (408 pages, $2.00) has been published by the Engineering College Research Council of the American Society for Engineering Education, University Heights, N.Y.C. 53. It provides an analysis and location guide for engineering and associated science research activities and capabilities in colleges and universities in the U.S.

10,000-mph Russian Rocket Plane?

Russia will be the first nation to produce a 10,000-mph rocket plane, Soviet scientist V. Alexandrov wrote in a recent Russian publication. He explained it would use intercontinental missile engines and a new high-energy fuel. Chief problem, he said, would be re-entry.

Lockheed to Add to Polaris Facility

The accelerated tempo of the Polaris weapon system was increased a beat recently when the Navy authorized Lockheed's Missile Systems Div. to start construction of an addition to the Navy-owned Polaris development facility at Sunnyvale, Calif., to provide manufacturing capability when the Polaris R&D phase is completed.

Film of Western Space Age Conference Available

A short documentary color film on the recent Western Space Age Conference in Los Angeles has been produced by ARS member Max B. Miller of 1420 S. Ridgeley Dr., Los Angeles 19. The 100-ft, 16-mm film is available for $17, or a 50-ft, 8-mm version for $7.50.

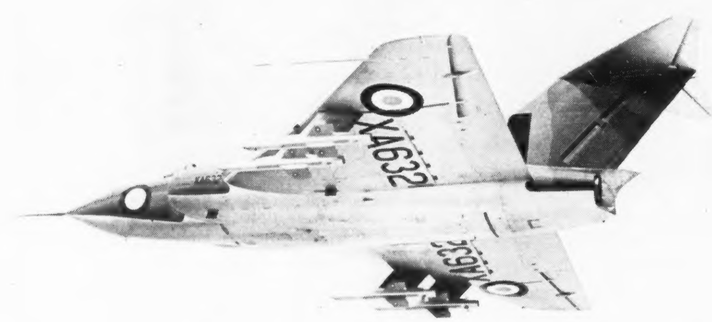
Canadian Astronautical Society Meets

The Canadian Astronautical Society held its second general meeting at the main plant of De Havilland Aircraft of Canada in Toronto, April 23, with more than 100 members and guests in attendance. The meeting featured an exhibition of rocket hardware built by society members, and illustrated lectures by N. G. Patterson of the Institute of Aerophysics, U. of Toronto, on atmospheric physics and high-speed, low-density phenomenon, and by A. B. Barnes, propulsion group leader, who described recent static rocket firings.

In his presidential address, P. A. Lapp reviewed the rapid progress the society had made since its formation last year, and indicated that experimental and theoretical activities were proceeding well in the several specialist sections. The group already has a membership of several hundred.

The society's temporary address is c/o De Havilland Aircraft of Canada, Guided Missile Div., Downsview, Ontario, and queries may be addressed to A. E. Maine, secretary.

Exhibition of rocket hardware was one of the Canadian Astronautical Society meeting features.



Powerhouse

British delta-wing Gloster Javelin packs four de Havilland Firestreak infrared guided missiles, can achieve speeds over 600 mph and altitudes over 50,000 ft.

East and West Meet

America's Boeing 707 (foreground) and Russia's Tupolev TU-104 jet transports were on display for visitors during the British Columbia Centennial Aviation Show at Vancouver International Airport in June.

Missile Market

(CONTINUED FROM PAGE 44)

investor will start off with a paper loss even before his shares are delivered. Contract awards carry the additional hazard of being totally unprofitable to a company for an awful long time before they start to favorably affect earnings. An unusually high yield is still another trap for the unwary investor, since it is often merely an expression of the belief that a company's dividend will soon be cut.

The merger talks between Northrop Aircraft and American Bosch Arma are further evidence of a continuing trend toward the emergence of "true" missile companies. Combining airframe, powerplant, guidance system and fuel under one roof is still the most profitable arrangement possible and would allow such a company to corral a much greater percentage of the top projects of the future.

It is not at all unlikely that five years from now half a dozen companies (which do not as yet exist as corporate entities but will be the result of a long chain of mergers in the industry) will account for 90 per cent of the missile business. This is the type of thing that has happened in practically every other major industry, although the evolutionary process has usually taken much longer. The nucleus of such corporate enterprises is already being formed. The pace is too rapid, the capital requirements too great, the speed of performance too demanding, and the personnel knowhow too rare for internal expansion to be successfully competitive with growth through merger or acquisition. The investor should beware of companies trying it alone.

Market Letter Gleanings

Goodbody & Co. recently gave out the following recommendations:

Buy—*Boeing, General Dynamics* and *Lockheed*
Hold—*Douglas* and *North American*
Switch—*Northrop* and *Ryan*

Other recent write-ups:

Boeing: Fahnestock & Co., Sprayregen & Co.

Lockheed: Francis I. duPont & Co.; Green, Ellis & Anderson.

American Bosch Arma: Joseph Faroll & Co.

Mine Safety Appliances: J. R. Williston & Beane.

Litton: J. W. Sparks & Co., Sartorius & Co.

Raytheon: Shearson, Hammill & Co.

Chance Vought: Halle & Stieglitz; Standard & Poor's; Paine, Weber, Jackson & Curtis; Henry Montor Associates, Inc.

Magnetic Recorder-Reproducer, Telemetry Standards Available

The Inter-Range Instrumentation Group (IRIG), composed of representatives of all U.S. missile test ranges of the three services, has developed and issued standards for telemetry and magnetic recording and reproducing systems. The telemetry standard carries the identification, IRIG Document No. 103-56 of 9 Oct. 1956, and the magnetic recorder reproducer standard, IRIG Document 101-57 of 14 Feb. 1957.

Copies of the standards can be obtained from the Armed Services Technical Information Agency (ASTIA), Document Service Center, Knott Building, Dayton 2, Ohio.

Space Age Symposium Highlights AWA Convention

A symposium on the subject of "Man in Space" highlighted the Aviation Writers Assn. convention held in Houston, Tex., in May, under the joint sponsorship of the Air Force and North American Aviation. Maj. Gen. Otis O. Benson Jr., commandant of the School of Aviation Medicine, Randolph AFB, Tex., presented a general statement and introduced the panelists.

Prominent speakers at the symposium included George P. Sutton, chief of preliminary design, Rocketdyne, and ARS president; Hubertus Strughold, research adviser to commandant School of Aviation Medicine; Walter T. Bonney, assistant to the NACA executive secretary; Scott Crossfield, NAA engineering specialist and test pilot; Capt. Iven Kincheloe, test pilot, ARDC Flight Test Center, Edwards AFB, Calif.; Joseph A. Walker, test pilot, NACA Flight Test Center, Edwards AFB; and Robert Roberson, NAA Autonetics Div.

XKDB-1 Sets Altitude Mark

A Navy XKDB-1 target missile launched at Pt. Mugu, Calif., has flown to a new unofficial high altitude record of 42,000 ft for remote-controlled targets in the medium performance class. The missile, designed and built by Beech Aircraft Corp., topped by some 3500 ft the previous mark, set in 1957.

Grumman's Super Tiger Jet To Be Produced in Japan

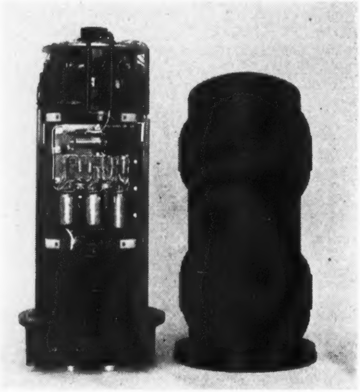
Japan's Mitsubishi Heavy Industries will serve as prime contractor in the production of 300 of Grumman Aircraft's Mach-2 Super Tiger jet for use by Japan's Air Self-Defense Force.

New equipment and processes

Low-Level PDM Commutator Breakthrough

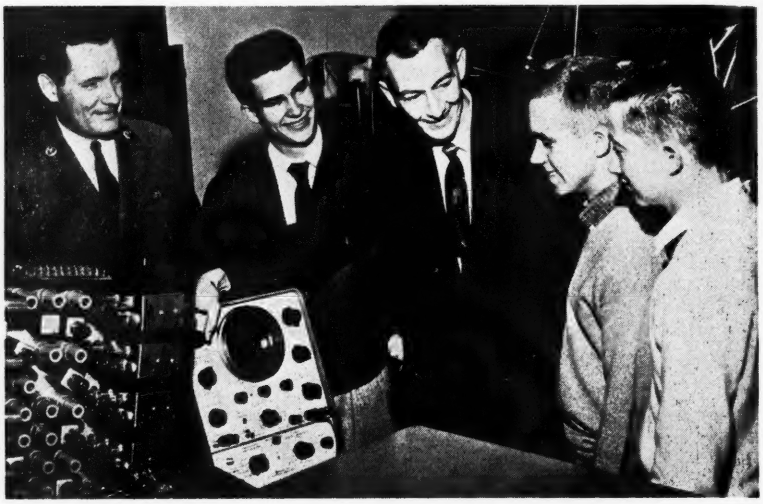
Transducers with outputs of a few millivolts are more accurate, usually smaller and lighter, and less expensive than their "high-level" counterparts, which currently give accuracies of about 5 per cent in the field (see May ASTRONAUTICS, "Cures for Which There Are No Diseases"). These "low-level" transducers have seen little use because (1) signal-boosting amplifiers introduce errors and are expensive and heavy and (2) mechanical commutators for the necessary low-level PDM telemetry equipment lasted only 20 or 30 hours in the field.

Consolidated Electrodynamics Corp., Pasadena, Calif., has now bridged the gap between the low-level transducer and PDM telemetry, tape recording and high-speed digitalizing with a commutator based on the recording galvanometer and a single photomultiplier tube. The instrument, a new production model of which is shown here, commutates and codes signals from up to 90 transducers at a rate of 112.5 signals per sec in any of four operating modes. The output, either 0.5 or 5.0 v peak-to-peak, can modulate directly an FM subcarrier oscillator or transmitter.

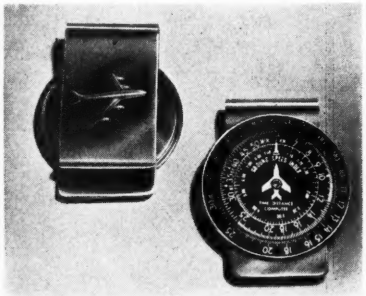


Consolidated Electrodynamics' low-level commutator, known as the Plexicoder, commutates and codes signals from up to 90 transducers at a rate of 112.5 signals per sec.

Hermetically sealed in an explosion-proof case, the instrument will operate in the range −65 to 100 F at altitudes of 100,000 ft. It has a nominal service-free life of 1000 hr, and can be repaired in the field by a technician. System accuracy is reputedly 1 per cent.



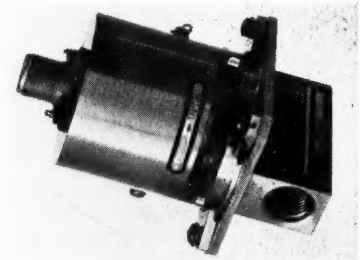
Scout Science Pioneers: A few members and advisers of Helipot Science Explorers Post 201 are pictured following charter ceremonies in the new Beckman Helipot plant, Newport Beach, Calif.



Pocket Computer: The Caidquinn time-distance-mileage computer, the size of a silver dollar, is available on lighters, key chains and money clips. Scales are reproduced on anodized aluminum alloys, utilizing an anodized facsimile technique. The computers can be used by pilots flying everything from Piper Cubs to high-speed military jets. Caidquinn, Inc., 147 E. 62nd St., New York 21, New York.

Adjustable Pressure Switch. The Electroset pressure switch described in Bulletin 1570, is vacuum-sealed, isolated from dirt, moisture or corrosive fluids, including the fluids used to actuate it. It is suited for applications where an adjustable switch must be located in a remote or inaccessible location or where the switch must operate in an atmosphere which would degrade the performance of a non-hermetically sealed unit. Among military applications are arming of warheads and control of missiles. Trans-Sonics, Inc., Burlington, Mass.

Thickness-Density Gage: The Gammascan measures the thickness or density of such continuously produced materials as plate and sheet metal, thick sections of plastics, etc. The instrument utilizes a modified scintillation detection method which senses the radiation from a sealed self-contained gamma radiation source, and continuously analyzes the thickness of the materials under inspection. An output signal is provided which can be used for control of servomechanisms to compensate for indicated variations. Nuclear Systems Div., The Budd Co., 2450 Hunting Park Ave., Philadelphia 32, Pa.



Solenoid Ball Valve: A two-way, two-position ball valve allowing straight-through flow with an equivalent orifice of 0.250 in. diam and 3/8 in. tube size is available in pressures up to 4500 psi and in a temperature range of −300 to +300 F. A momentary electrical surge of approximately 2.5 amp is required for actuation. A 24 v dc solenoid is furnished when electrical specifications are optional.

Pneu-Hydro Valve Corp., 364 Glenwood Ave., E. Orange, N. J.

PRODUCT LITERATURE

Precision Potentiometers. George Rattran & Co., 116-08 Myrtle Ave., Richmond Hill 18, N. Y.

High Energy Power Sources. Frank R. Cook Co., Denver 23, Colo., vol. 1, featuring Micropoise relays. Cook Electric Co., 2700 Southport Ave., Chicago 14, Ill.

Linear Servo Accelerometers. Data file 410. Donner Scientific Co., Concord, Calif.

Micro-Miniature Connectors, series MM22. Electronic Sales Div., DeJur-Amsco Corp., 45-01 Northern Blvd., L. I. City 1, N. Y.

Flawmaster Epoxy-Based Metal Putty. Carl H. Biggs Co., 2255 Barry Ave., W. Los Angeles 64, Calif.

Belleville Springs and Spring Washers. Technical brochure. Union Spring & Mfg. Co., New Kensington, Pa.

Tape Cable. Technical data on thin copper conductors imbedded in transparent polyester. Tape Cable Corp., 790 Linden Ave., Rochester 10, N. Y.

Variable Transformers Bulletin 151. Ohmite Mfg. Co., 3668 Howard St., Skokie, Ill.

Data on relay types—variation in spring arrangement, timing, coil voltage, and other classifications. Cook Electric Co., 2700 N. Southport Ave., Chicago 14, Ill.

High Rate Tester Engineering Bulletin 625-1. Allegany Instrument Co., Inc., Cumberland, Md.

Modern Testing Methods. Brochure on circuit analyzing equipment. DitMco, Inc., 911 Broadway, Kansas City, Mo.

Ultrasonic Testing Services and Equipment Bulletin 50-107. Sperry Products, Inc., Danbury, Conn.

Precision Metal Forming—deep drawing, spinning, hydroforming, annealing, spot welding, assembling and tool making. C. B. Kaupp & Sons, Newark Way, Maplewood, N. J.

Testing Services—environmental and qualification tests, design evaluation, research and development, etc. Aerotest Laboratories, Inc., 129-11 18th Ave., College Point 56, N. Y.

Centrifuge Acceleration Test Machines Bulletin S-1. Rucker Co., 4707 San Pablo Ave., Oakland, Calif.

Burcap Splicing Connector Data Sheet. Omaton Div., Burndy Corp., Norwalk, Conn.

High-Temperature Brazing

(CONTINUED FROM PAGE 29)

shows a typical sandwich structure of two 0.010-in. stainless steel facings combined with a $^{3}/_{16}$–0.0015 in. honeycomb core $^{1}/_{2}$ in. thick. This kind of structure permits full utilization of facing physical properties in tension, compression, bending, shear and torsion. In addition, the brazed sandwich has excellent resistance to intense sound vibrations and high insulating capacity. No other fabricated structure is as efficient on a strength-to-weight basis.

Intensive research during the last seven years has developed filler materials adequate to join important structural alloys—such as the stainless steels, the so-called "super" alloys and the hot-work tool and die steels—in practically any combination. Layup and firing techniques have also been developed to minimize brazing difficulties. Now, when the space craft designer demands structural assemblies that are as light as possible, but rigid, capable of holding internal pressure, supporting payload, and resisting forces due to acceleration and bending moments, we can reply: "Brazed sandwich offers excellent potential for the application."

Brazed honeycomb structures also offer a partial solution to aerodynamic heating problems. All-metal sandwich has excellent resistance to thermal stress, fatigue and rupture. For example, a cantilevered brazed honeycomb-sandwich strip 1 $^{3}/_{4}$ in. wide by 12 in. long by $^{1}/_{8}$ in. thick was subjected to a dead weight causing skin, or facing, stress of 10,000 psi in a furnace at 1500 F. The core was 0.002 in. foil in $^{1}/_{4}$ in. square cell pattern produced on Solar's automatic resistance-welding core machines; base metal was Haynes Alloy 25. A nickel-based, high-temperature corrosion-resistant brazing alloy bonded the assembly. After 64 hours there were only slight indications of compression buckling at the supporting edge of the strip.

Sandwich Readily Modified

Brazed all-metal honeycomb provides the designer with an important material for another reason: Modifications can be made to meet specific requirements. For example, basic sandwich can readily be modified to provide improved insulation, internal pressurization and fluid flow.

Moreover, large increases in thermal resistance can be achieved by incorporating refractory fillers in the core. To illustrate the insulating properties of refractory sandwich, a section was used as the door of an electric furnace at 2120 F, as shown in the photo on page 29. This door was made of 0.010-in. Inconel facings with 0.005 in. wall, $^{1}/_{4}$ in. square cell core of 0.235 in. thickness, high-temperature brazed with a nickel-based alloy designed for operating conditions up to 2000 F.

The top diamond spot shows an exposure of inner skin, which was at an optical temperature of 1740 F as measured under blackbody conditions. The bottom diamond shows directly through into the furnace (at 2120 F). The outer skin temperature was about 1570 F. Lower furnace temperatures would show greater thermal drops with the same honeycomb sandwich. The interesting core-cell pattern on the door section shows the direct conduction of heat through the core to areas of facing contact. The contact area is approximately 100 deg hotter than adjacent areas. Evacuated cells using nonpermeated core have been successfully constructed and tested, and have shown even greater thermal drops.

Such thermal barriers are needed in aircraft, missiles and spacecraft for firewalls, ducting, blast cowls, fuel tanks and many other structures.

Brazed honeycomb also offers pos-

sibilities for internally pressurized structures. Sandwich like that shown at the top of page 28 shows scattered cell failure at 1300 psig and complete core failure at 1500 psig, pointing up its high-quality facing-to-core bond characteristics.

An evacuated or gas-filled sandwich would thus appear to offer useful properties for space vehicle skins. The double-wall construction should provide both significant meteorite protection and a means of localizing damage

Serves as Fluid Carrier

Highly refined fabricating techniques have made it practical to produce brazed high-strength sandwich with one or both faces of a perforated or permeable metal. These are designed for applications requiring fluid flow through a skin for either cooling or heating. The familiar term, "sweat cool" material, has increased significance with this type of integrated structure. A composite has the strength-to-weight advantage of all-metal sandwich in addition to serving as a fluid manifold. And, because the core is an exceptional facing stabilizer, very thin skins are feasible, with a consequent reduction in pressure drop and panel weight. Possible applications for porous-face sandwich include sweat cooling, aerodynamic bleed, boundary layer control and filtering.

However, brazing should not be considered restricted to sandwich fabrications. While high-temperature corrosion-resistant brazing to increase the reliability of rocket combustion chambers has not yet been fully exploited, it is anticipated that this method will provide increased rupture strengths and better resistance to fatigue. A promising sheet material for high-temperature, high-strength applications is hot-work tool and die steel. Also showing promise for brazed structures are 5 per cent chromium, molybdenum and vanadium air-hardening alloys such as Vascojet 1000, Potomac A, etc. Base-metal tensile strengths of over 200,000 psi are obtainable at 1000 F.

The low elongation of these materials when hardened to maximum strength necessitates precision uniform joints. Pressure fittings are of particular importance. Fusion welding difficulties in attaching pressure fittings to experimental tanks, which caused frequent failures at low hoop stresses, have been eliminated by brazing with a suitable filler.

Current large missiles use liquid-propellant rocket engines requiring heat exchange in combustion chambers (regenerative cooling), pumps, ducting and associated equipment. Brazing is now being used to gain low-weight, reliable heat-exchanging structures in liquid engines.

Reliable high-pressure bellows and couplings with zero leakage for the fuel system are mandatory, and brazing is particularly applicable for joining the dissimilar materials involved in such assemblies to provide uniformly high-joint strength with maximum fatigue resistance. Brazing produces high-pressure fuel lines with long, trouble-free service life for reciprocating engine manifolds. Also, gas turbine reliability and efficiency have been improved during the last three years through the use of brazed honeycomb core for labyrinth and blade-tip seals.

Brazing-alloy developments and new and novel techniques of use provide practically unlimited combinations of materials and designs for missiles and space vehicles. The photos at the bottom of page 29 show some applications of brazing along these lines. The composite structure with the waffle core shows potential for fuel storage and damage control for space ships. The little control unit, designed for high-temperature operation, was fabricated by a series of brazings in which the first were reheated to the temperature of subsequent ones. Several fillers were used in the fabrication step. This control unit shows considerable precision of assembly. Joints do not deform or loosen, because the brazing filler and base metal undergo atomic diffusion and develop a bond with a higher melting point than that of the filler. The marcel sandwich and sandwich-supported tubing sections show the ready adaptability of brazed sandwich structures to lightweight heat exchangers and circulation systems.

Creative imagination and extensions of practical designs already in existence offer potential solutions for the types of problems which will be encountered in the space flight age.

New Brazing Alloys for Rocket, Missile, Reactor Parts

Engineers are turning more frequently to stainless steel and other heat-resistant alloys as operating temperatures for rocket, missile and nuclear reactor parts climb above the 1000 F level. These alloys require brazing fillers that flow, wet and bond at moderate pressure in production processes, and give the necessary strength and oxidation resistance at high-temperature joints. The accompanying table shows some brazing fillers that promise to meet such requirements.

The silver-base lithium alloy allows brazing of stainless steel without flux at a temperature as low as 1600 F in an atmosphere. This alloy, in place of silver-manganese filler, reportedly reduces the rejection rate of honeycomb panels of stainless steel from about 50 to 10 per cent, which may make honeycomb price-competitive as standard structural material. Also, small amounts of lithium with silver-copper and silver-manganese eutectics now braze steel bellows, instrument assemblies, hydraulic lines and various jet engine parts.

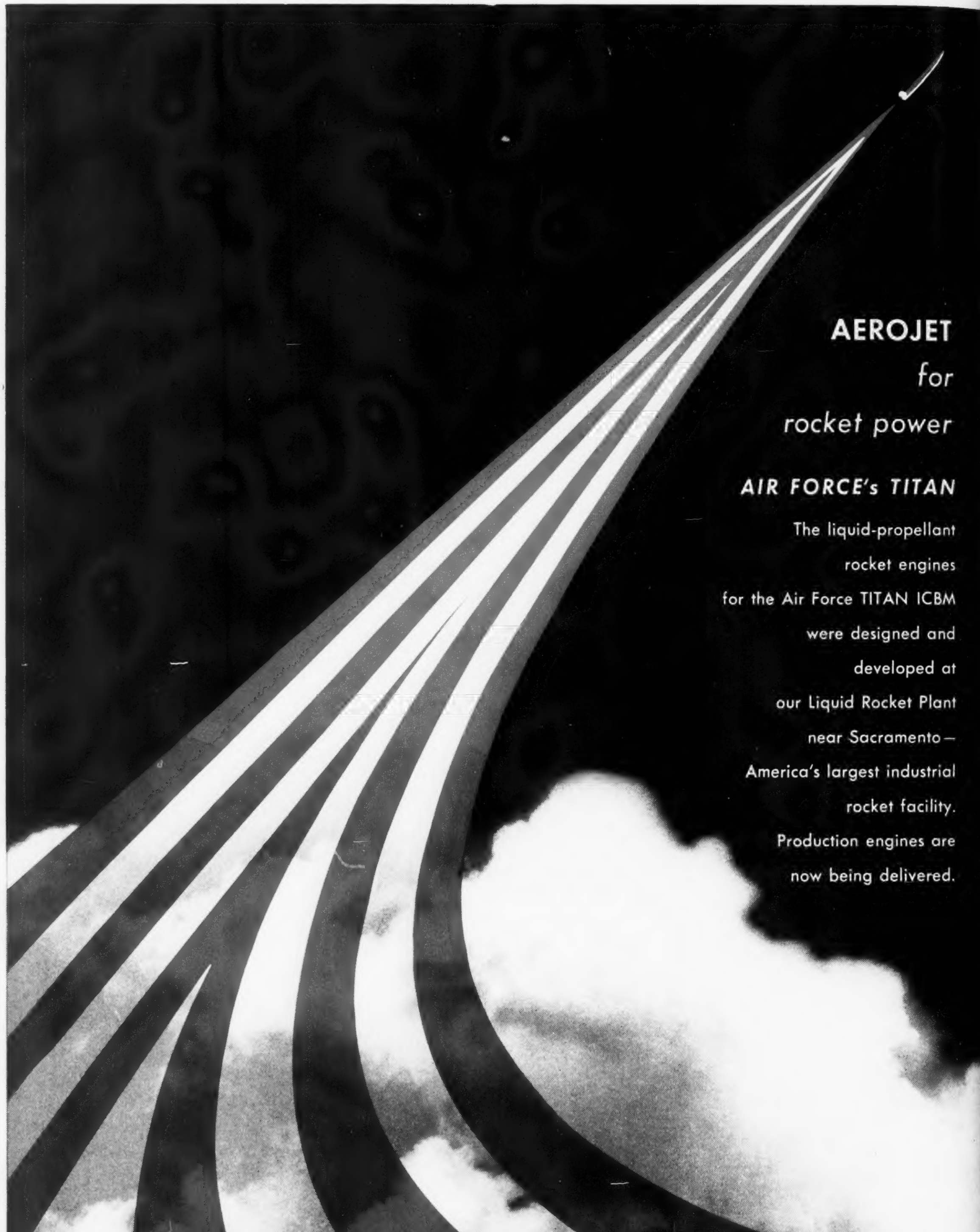
Silver-palladium and manganese-nickel are also under study, the latter for heat exchangers, rocket motor parts, clad metals and turbine blades. Nickel - silicon - boron - chromium appears unsurpassed for hardness and strength in the 1600–1800 F range, but attacks many metals by intergranular penetration and solution. Gold alloys, which are non-penetrating and give excellent strength and oxidation resistance around 1600 F, are under study for critical missile and reactor parts, where need for reliability far outweighs cost of the gold for joints. Brazed to stainless steel, gold-chromium-nickel has been heated in air to 1600 F for seven days and retained a tensile strength of 20,000 psi.

NEW FILLERS FOR BRAZING HIGH-TEMPERATURE ALLOYS

Filler (Per cent Composition)	Melts °F	Flows °F
Ag(92.3)-Cu(7.5)-Li(0.2)	1435	1635
Ag(90.0)-Pd(10.0)	1835	1950
Mn(70.0)-Ni(30.0)	1840	1875
Ni(72.5)-Cr(16.0)-Si(5.0)-B(3.5)*	1825	1840
Au(72.0)-Cr(6.0)-Ni(22.0)	1785	1835

* Balance, Fe

Index To Advertisers


AEROJET
for
rocket power
AIR FORCE's TITAN
The liquid-propellant rocket engines for the Air Force TITAN ICBM were designed and developed at our Liquid Rocket Plant near Sacramento — America's largest industrial rocket facility. Production engines are now being delivered.